THEORY AND PRACTICE OF DAMASK WEAVING

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OF

DAMASK WEAVING

BY

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PREFACE.

THE different technicalities of damask weaving have not yet been the subject of an exhaustive treatise.

So far only scattered articles in books and trade papers have dealt with this department of textile manufacture. The books treat briefly of the principles of the art, the journals give minute descriptions of novelties in looms. A desire has therefore been expressed by manufacturers of damask to possess a manual in which the present condition of the industry is fully dealt with. This work is intended to respond as fully as possible to this desire, for it instructs not only in the simple applications of Jacquard weaving to the industry, but in the accessory processes which it has been found advantageous to add.

The fabrics mentioned in illustration of the theoretical part of the work have been made from original patterns, and will contribute to a general comprehension of the whole subject.

In the same way, the figures given in the text and in the plates will much facilitate the understanding of the methods and give a general view of the matters treated of.

The numerous and minute researches which the authors have carried out appear to justify them in publishing their experiences. No pains have been spared in the preparation of the illustrations.

In conclusion, we must not omit to express our great gratitude to Director C. A. F. Knorr, of Chemnitz, who was kind enough to revise our manuscript.

THE AUTHORS.

JÄGERNDORF AND RUMBURG,
February, 1901.

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INTRODUCTION.

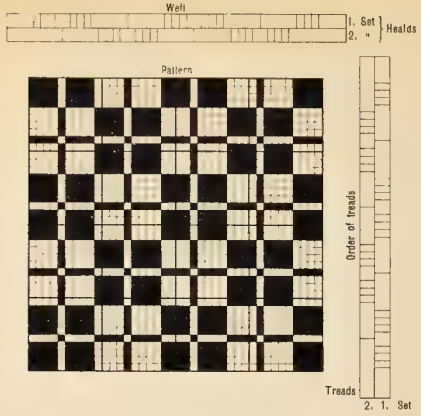
The manufacture of damask is without doubt a very old branch of weaving. Our forefathers knew long ago how, with very little extra complication of the loom, to raise the warp by the healds in different parts in such a way as to get large patterns.

The damask of long ago was a figured fabric of a simple kind (see hand-made drill) made in Eastern Asia, especially in China. Thence the manufacture extended to the West, and the manufacture was carried on at Damascus, whence the fabric gets its name.

The pattern was produced by alternating simple weaves with bare stretches of warp, changing after inserting a certain number of weft threads. Until 1604 the oriental loom was still used in Europe. It contained a number of ordinary healds as well as the front set of healds which is still indispensable. With this loom many check patterns which we shall describe later were produced, and although it was comparatively simple, it was the means of making these wonderfully beautiful fabrics which are still among the best specimens in our museums.

This simple apparatus is, however, no longer sufficient. Improvements follow on improvements, with the object of getting the best results in the simplest possible manner. All these shall be explained to the reader in this work.

Fig. 1.



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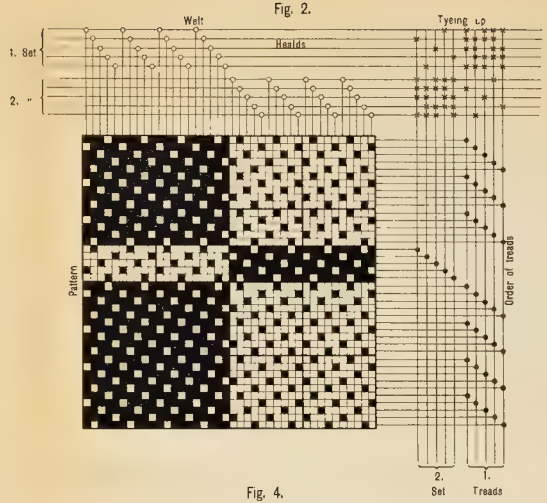

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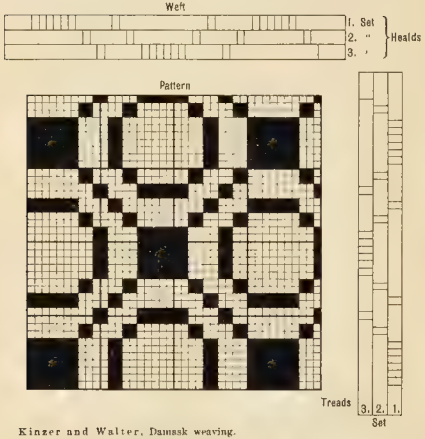


Fig. 4.

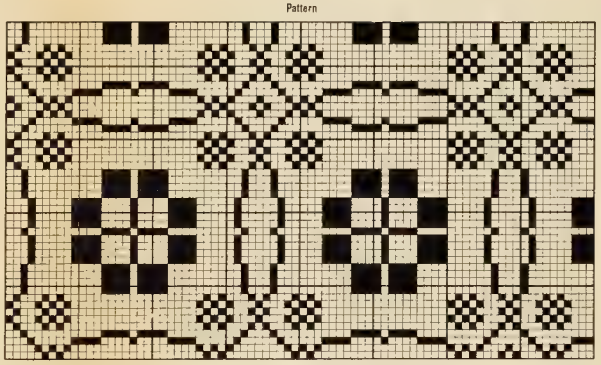
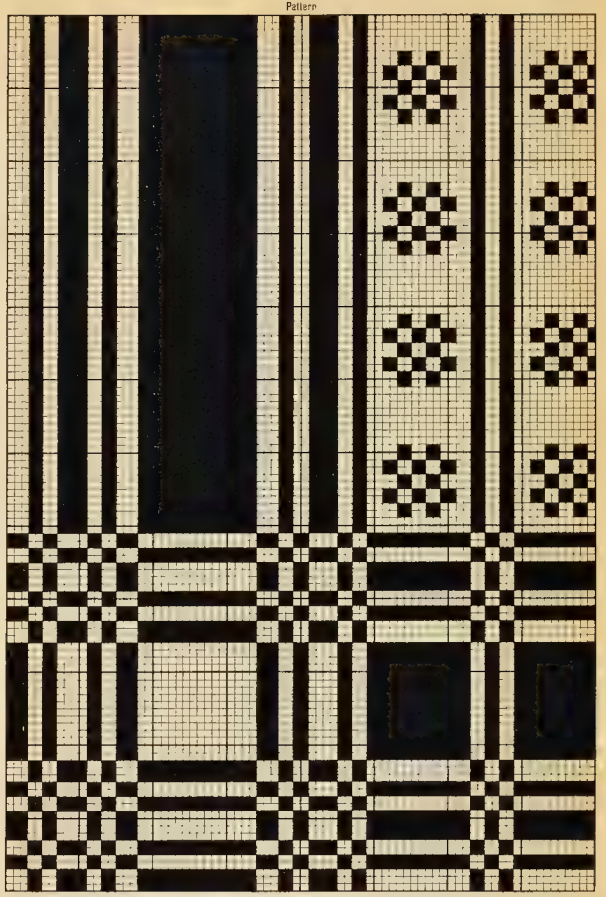


Fig. 5.



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PART I.

THE VARIOUS SORTS OF DAMASK FABRICS.

CHAPTER I.

DRILL (TICKING, HAND LOOM MADE).

THE chessboard-like check patterns must be regarded as the forerunners of the damask weaving of to-day. They are fabrics in which the warp and weft sides of a twill or atlas interchange in square figures.

Under the heading of Drill we include all smooth twills with right-angled patterns usually produced in a hand loom. The pattern is produced by interchanging the warp and weft sides of a twill or atlas cross weaving in square forms. The number of threads depends on the size and closeness, and is always a multiple of the cross-weaving ratio employed. Check patterns are classified as two-part and many-part. In the former case there are only two transpositions, giving a draughtboard appearance. The pattern is three- or four-part, and so on, according to the number of transpositions. In representing these patterns pictorially it is not necessary to show the separate warp threads, and it is usual to take a small field or point on the paper for a whole place of union between warp and weft. Fig. 1 (Plate I.) is a sketch of a two-part check pattern. The black spaces denote warp, the white weft, of a five-fold atlas.

If the first four lots of warp are compared with the fifth, it will be seen that it is the reverse of the four, while lots six to nine inclusive are the same as the first four. Lots ten to thirteen inclusive are like the fifth, while the fourteenth is like group one

and three, and so on. This proves that the pattern is only two-part although it shows right angles of different sizes. The corners of the parts of the pattern abut against one another, and an isolated figure cannot be produced. As already remarked, one field of the sketch always denotes the whole one place of union of warp and weft, or in other words, a warp line in the sketch corresponds to five warp threads in the fabric. Fig. 2 (Plate I.) explains this further. The lower left-hand corner in Fig. 1 shows four threads of atlas warp in square, and these four appear in Fig. 2 as twenty, separated in the five-leaved atlas. As is well known, five shafts and five treads are used for this weave, so that the first square contains four repetitions, *i.e.*, five sets of healds are four times in the same order. The result is that it is possible to decide from the pattern sketch not only the number of healds and treads required, but the complete weft and the arrangements therefor. Fig. 1 (Plate I.) is two-part, and as each part corresponding to the ground weave wants five healds or five treads, ten of each are required altogether.

The first similarly woven group in the figure contains four warp lines, and therefore four sets of five threads must be carried by the first five healds. The second group is only one warp line broad, so that there is only one set of five threads inserted in the front five healds. The third group, again, contains four sets in the back healds, the fourth and sixth groups contain four sets in the front healds, and, finally, the fifth group has one set in the back five healds. This succession is repeated *ad lib.* Hence, the harness necessary for such work is divided as follows :—

Healds 1-5	20		20		5		$45 \times 10 = 450$ lifting heddles.
Healds 5-10		5		20		20	$45 \times 10 = 450$ lifting heddles.

10 times.

If then the fabric is, say, 900 threads wide, the ratio will be repeated ten times, and the lifting eye numbers above given apply to every five healds.

In towelling and tablecloth goods the weaving is always ended

with the same figure with which it was begun. In this case we should give the width forty-five threads more or forty-five threads less. With forty-five threads more we should repeat the series ten and a half times, and with forty-five threads less, nine and a half times, so as to get similar stripes left and right. This pattern was formerly exclusively produced by counterpoised healds, for the following reasons. As is plain from Fig. 2 (Plate I.) the first twenty weft threads, counted from below upwards, require only five treads, while the next five require five more treads, and the following wefts are woven with the first five treads, so that there are two sets of treads. The healds are arranged in two lots, and it will depend on the width of the pattern fields how many lots of warp are used, one upon another, for a division of the pattern, *e.g.*, twenty threads in four lots, or forty in eight, and so on. The length of the pattern fields will depend upon how often the weaver, in filling, moves one or the other division of the treads in succession. Hence the number of weft threads in a right-angled pattern always corresponds to a multiple of the cross-weaving ratio.

Once the work has been arranged for a particular pattern, the weaver cannot alter the warp during the weaving. In other words, all the right angles of the pattern will receive the destined number of warp threads. The length (number of wefts) of the right angles, however, can be regulated at his pleasure, for he can work any one set of treads as often as he wants. This gives him the power of making new patterns by means of the weft, for there is no limit to the number of wefts. It would, for example, be quite possible to make the pattern on a towel run the whole length, so that there is no repetition whatever. But, if the loom were fitted with ordinary healds, as many cards would be required as weft threads in the whole, *i.e.*, perhaps many hundreds.

To prevent this, healds have been made of late, especially for power looms, which admit of repeating a weave as often as desired with the same number of cards, so that the whole weaving is done exactly as on a hand loom.

Fig. 3 (Plate I.) is a three-part check pattern. The simultaneous connections in the warp are:—

1st group with 7 threads or sets.
4th ,, ,, 2 ,, ,,
8th ,, ,, 2 ,, ,,

The second, fifth and seventh groups with two sets each, the third with two sets, and the sixth with seven.

The weft is the same. The resulting squares and right angles now no longer abut against one another and can form quite separate figures. The number of healds necessary depends on the ground weave, *e.g.*, for four-leaved twill it is $4 \times 3 = 12$, for five-leaved atlas, $5 \times 3 = 15$, and the same number of treads.

Fig. 4 (Plate I.) is a four-part check pattern. The whole series includes thirty-four sets in warp and weft = 136 threads, with a four-leaved twill ground weave.

Fig. 5 (Plate I.) is a sketch for a towel in four-part check pattern. The long and short edge includes forty-nine sets, a repetition in the ground twenty sets in the warp and eighteen in the weft.

Of late attempts have been made to make even complicated drills on the power loom without needing such a large number of cards, and success has been achieved by an arrangement due to Hermann Terfloth of Laer, and shown in Figs. 6-8 (Plate II.). The chief object of this machine is to work with fewer cards, by substituting for the usual cards a perforated prism and a chain of small links. As in other arrangements, lifters, P (Fig. 6), are connected with each heald. The lifters rise and fall by means of a knife, M, or by a sinking lifter-carrier, P, *b*. The batten, L, turnable round the roller, *c*, receives a corresponding swinging movement against the needleboard, and the prism, P, *r*, inserted below in the batten, is turned by a gear, so that at every advance of the batten a different side of it is presented to the needles which govern the position of the lifters. While up to now the prism was perforated for every needle, and the perforations were closed according to any given pattern by pasteboard cards, the prism itself in this contrivance is perforated according to the desired ground weaves, and the upper rows of holes form one of them,

the lower rows the other, so that for example the upper make a warp atlas, the lower a weft atlas (Fig. 8, Plate II.).

For the majority of these fabrics it is only a question of making four-leaved warp and weft twill or five-leaved warp and weft atlas. In the latter case a five-sided prism is used. A second mechanism allows the needles to be arranged in front of the upper or lower row of holes in the prism. The needleboard consists of several parts, N_1, N_2, N_3, which rise and fall vertically and are kept at the right height by the roller-lever, *h*, whose rollers, *r*, rest on the pattern-chains, E, K. The chains are worked by cams according to the pattern (Fig. 7, Plate II.). The number of needles to a division is the same as the number of healds.

The changing of the needles is effected by turning the prism, P, *r*. On account of the spur-gearing, Z_1, Z_2, Z_3, the roller, *c*, is turned in the same direction as P, *r*. The roller, *c*, also gears by the wheel G with the wheel S_2. The latter therefore with the chains, E, K, is turned with the fifth turn of the prism, and puts the needle-positions in place for the next five wefts, corresponding to the arrangements I.-VI. (Fig. 8, Plate II.), high or low, whereby the healds act for the proper number of threads, warp or weft atlas. By reversing the chains, E, K, or by another arrangement of the upper parts of the chains, new patterns may be produced without much loss of time, and without further expense, instead of having to put in fresh cards, as is necessary with the present arrangement.

The already described arrangement is enough for piece goods. But so as to be able to weave with the shortest possible chains uninterruptedly, a gearing is provided, whereby the chains can be driven backwards or forwards.

The wheel, G, of the roller, *c*, is double, and fixed to *c* with a nut and a spring. In the position shown in the figure it turns the roller, *a*, directly by means of S_2, while in the right-hand position, the roller, *b*, and two equal-sized cog-wheels, Z_4 and Z_5, and wheel, S_1, the roller, *c*, is turned in the opposite direction. Hence an automatic adjustment of the double wheel, G. For this purpose the roller, *a*, carries a chain, E, K_1, with the same number of links as E, K with low cams and two high ones, the latter being inserted

as first and last part of the chain. A high link of the chain, E, K_1, by means of the lever, h_1, and also the connecting rod and the knee lever, h_2, h_3, brings the adjustable wheel, G_1, of the roller, c, into gear with a cog-wheel, S_3. The latter is connected with a shorter cam chain, E, K″, which adjusts the wheel, G, by means of the rolling lever, L, and the double lever, h_5, h_6, resting on h. A high link of the chain, E, K″, leaves G geared with S_2. A lower one, by means of the spring, y, connects G to c, and gears it with the wheel, S_1, and the roller, b. Hence by various arrangements of high and low link in the chain, E, K″, the gearing of G may be arranged at pleasure, so that the arrangement gives a number of repetitions of the middle piece or the length of a cloth.

According to Fig. 7 (Plate II.) there are two weave effects, twill and atlas, obtained with different positions, while the ground work is atlas. In former times, before the discovery of the Jacquard machine, the production of check patterns was a special branch of linen and tablecloth weaving. The division of the pattern was further extended, and figures even with a large number of threads were produced by hand looms alone. With the complication of the pattern the number of healds required also increased, and very soon reached an unexceedable maximum. Hence new devices were sought for, and two separate sets of healds were introduced. The hinder set had the usual cord mails, and the number of healds corresponded to the divisions of the pattern. All the threads of one part of the pattern hence went to the same heald. In this way it was possible to complicate the pattern up to twenty parts and more. Pattern Fig. 4 (Plate I.), for example, was made with this arrangement, and with a four-leaved twill weave required only four healds instead of sixteen. These four must be threaded in the following manner:—

Heald 1, first part with 4 threads together
,, 2, second ,, ,, 4 ,, ,,
,, 3, third ,, ,, 4 ,, ,,
,, 4, fourth ,, ,, 4 ,, ,,
,, 1, first ,, ,, 4 ,, ,,

and so on.

This is easily seen from the drawing. If one of the four healds rises, it lifts four threads. Thus, for example, in the first line of Fig. 4 (Plate I.) the second heald would have to rise, whereby in the first combination the second, sixth, eighth, second, eighth, thirtieth and thirty-fourth groups of four warp threads form the upper shed, and so on. Now, as a field in Fig. 4 (Plate I.) corresponds to four warp threads the threads will also be lifted in lots or left down in lots. Thus, for example, the groups nine to twenty-seven of the first weft line remain in the lower shed. These nineteen groups correspond to $19 \times 4 = 76$ warp threads, which in this case are not lifted. The result is that some arrangement must be used for securing the close combination of warp and weft over the whole width of the piece. This is done by inserting the second set of healds with as many healds as the ground weave requires. The mails of this set are usually long, *viz.*, six to seven cm., so that the threads can be moved up and down without altering the position of the healds. In the second set, the front or cross-weaving set, the warp threads are threaded singly in the usual manner. The back healds had therefore the object of lifting the warp threads in groups without cross weaving, while the front healds managed the appropriate cross weaving, one of them rising as the other fell.

A glance at Fig. 59 (Plate VIII.) will make this clear: h_1 and h_2 are two pattern healds, and V and W are the front or cross-weaving healds. As is plain, the threads are passed in groups through the eyes of h_1 and h_2, and singly through the long mails of the eight front healds; h_2 is drawn upwards, so that the warp threads lie five to eight in the upper shed. If now the first front heald, for example, is lifted, one thread of the four left lying will also be raised, and if the fifth heald is lowered, the fifth thread will be lowered, although it is raised by the pattern heald, h_2. Thus regular weaving is ensured.

Just as the healds were arranged in two sets, so were the treads. The weaver formed the shed with both feet at once, working with one foot the tread lifting the pattern heald, and

with the other the tread moving the cross-weaving heald. These treads had to be changed at each pick, and their number corresponded always to the weaving ratio of the ground weave.

The number of pattern treads was arranged according to the division of the pattern in the weft, so that for Fig. 4 (Plate I.), for example, four pattern treads would be needed, and, with four-leaved twill, four weave treads. The pattern treads were not altered at every pick, but only after the necessary weft to form the width of the check had been thrown. The use of the treads in Fig. 4 (Plate I.) would be, for example :—

On the first pattern tread, remain motionless for 4 wefts
,, second ,, ,, 4 ,,
,, third ,, ,, 4 ,,
,, fourth ,, ,, 4 ,,

and so on.

During this, however, the weave treads are worked right on. The pattern treads work the pattern healds, the others the weave healds only. This arrangement gives a greater possible variety of patterns than before, but it soon reached its limits, and only the invention of the Jacquard machine brought the art of weaving to greater perfection.

We have now shown that by the use of two sets of healds the pattern may be made in twenty parts or more. If we replace the pattern healds by a Jacquard machine, we may get as many parts as there are sinkers.

Fig. 6.

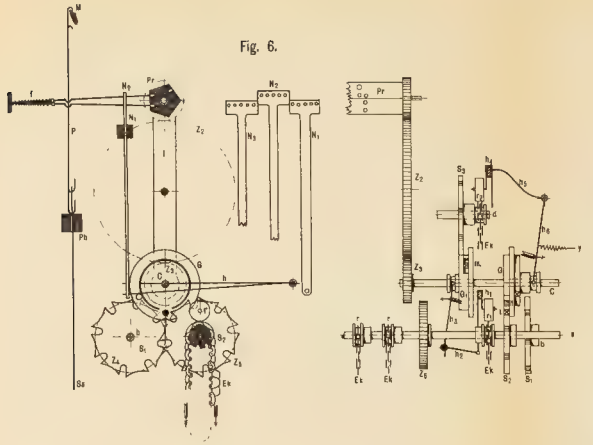

Fig. 7.

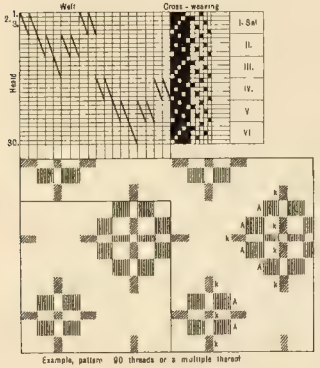

Fig. 8.

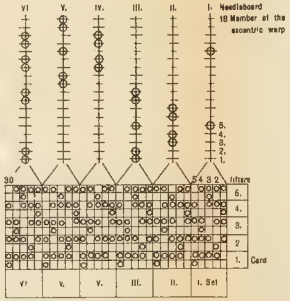

Fig. 9.

Example of silk damask pattern, half natural size.

Fig. 17.

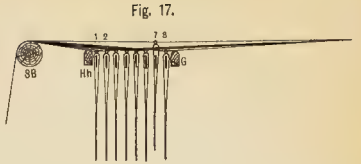

Fig. 14. Fig. 16. Fig. 15.

Fig. 10.

Kinzer and Walter, Damask weaving.

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CHAPTER II.

WHOLE DAMASKS FOR TABLECLOTHS.

THESE damasks contain large patterns with more complicated and finer designs than the drills, showing, for example, flowers, ornaments, landscapes, figures, inscriptions, etc. (see Fig. 9, Plate II.), executed in atlas or twill, whereby the side on which the weft forms a figure is considered the right side, because the predominance of the finer warp yarn in the ground gives this a finer lustre and one which shows up the pattern better. These fabrics are universally used for tablecloths, napkins and towels, and are worked with middle and corner patterns and a framing pattern.

1. ORDINARY DAMASK.

In the usual Jacquard machines and simple arrangement of threads, the warp ratio of the pattern is the same as the number of sinkers. Every sinker contains so many cords as there are ratios or repetitions over the width of the fabric, *i.e.*, as many as the quotient of the total number of warp threads by the number of sinkers. With a 400 machine of coarse spacing, for example, the pattern may take 400 threads, or with the reserve sinkers, 408. If, however, the width of the fabric contains 1200 threads, we have $\frac{1200}{400} = 3$ repetitions, and each sinker, from 1 to 400, receives three threads, an eye to a thread. Within the limits of these 400 threads the designer has free scope. He can give to each one the arrangement he chooses, and the outline of the pattern can change with a single thread. If to every lifter two mails each with a thread are attached, the warp repetition is increased to 800 threads, of which however the two threads

of each pair will get the same movement, being in the same heald.

If four mails are put to every lifter, the repetition becomes 1600 threads. Hence the pattern becomes four times as big, but single threads can no longer be altered, as they work together in the healds in fours. The outline of the drawing in the fabric will no longer change one thread, but four threads at a time. This is a distinctive feature of damasks. If in a damask we have equal closeness of warp and weft, and equal thickness of material, this change by four threads must also take place with the weft, for otherwise, with equally divided pattern paper and only single thread changes in the weft, the drawing would appear distorted, as although it would be of the right width, it would only have one quarter of the proper length. The case would be different if the closeness of the weft was only half that of the warp. Then two weft threads take up as much room as four warp threads, and the correct proportions of the design will appear, with a change of only two weft threads.

In the simple Jacquard fabric the weave point of the pattern is the element, and consists of separate single points each of which corresponds either to a raised or lowered warp thread. In damask-like goods the matter is altered in so far as the pattern also consists of single points, which in the fabric, however, mean not merely one but a group of warp threads. Hence the point in the design corresponds to the raising or lifting of so many contiguous warp threads. Hence the designer must mark the pattern paper not according to the number of threads, but of groups of threads, in warp and weft.

In designing, the cross weaving of threads lying bare too far cannot be indicated because a point on the paper corresponds to a whole group of threads, so that the cross weaving of the pattern drawing would be formed by more than one warp thread. Such places in a damask pattern, which appear as twill atlas or linen, are not to be considered as fabric formation but as effects having the object of showing up certain parts of the figuring more or less. After the execution of a design for ordinary damask, smaller or

larger sets of the sinkers are raised close together or left in the lower shed. For example, it may happen with straight lines in the weft that the whole of the healds are raised or left lowered. This brings all the warp into the upper shed or leaves it in the lower. But of the lifted warp threads a number corresponding to the weave wanted must be brought into the lower shed, or *vice versâ*. Hence comes the question how the regulation of single warp threads is to be secured. As it cannot be done with the Jacquard machine, some other means must be discovered, and it consists of the front healds already described in connection with check patterns.

These front healds raise single threads according to the weave required, and which are left behind in the lower shed by the Jacquard and brings back into the lower shed others which the machine has lifted. It is to be remarked that only a small part of the warp threads is moved by the healds, so that all parts of the figure, where the lifting forms the upper shed, will appear on the warp side of the weave, and the other parts, where the upper shed is formed by means of the healds, on the weft side.

This rising and falling of the front healds is managed independently of the Jacquard. Hence the shedding consists of two distinct operations, the movement of the Jacquard and that of the front healds. This requires that the Jacquard must not interfere with the action of the front healds, so that the construction of the lifting eyes must differ in the front healds from the ordinary construction.

Fig. 10 (Plate II.) will show this better. On each of the sinkers, P, *t* and P, *h*, of the Jacquard, T, M, hang four cords, H, S, which go through the round bars of the grating, R, and the comber board, and carry the lifting eyes, H_1-H_8. One warp thread is put through each mail, so that each sinker regulates four threads. These warp threads are therefore not only in the mails of the Jacquard, but pass also through those of the front healds, S_1-S_8.

The mails in the front healds are long, as already described for check patterns. As shown by the figure, P, *h* is lifted and

P, *t* is left down. Hence, threads one to four are shown in the upper, threads five to eight in the lower shed. The machine then always lifts in groups, without cross weaving, and Fig. 11 shows the resulting shed. The weave of the figure is the business of the front healds, which are moved by various contrivances to be described later. In this double shedding we have the greatest disadvantage of damask weaving, the so-called cross shedding, which is shown diagrammatically in Fig. 10 (Plate II.), and in perspective in Fig. 13, p. 14; Fig. 11 shows the Jacquard shed. Part of the threads is raised in masses, but where this

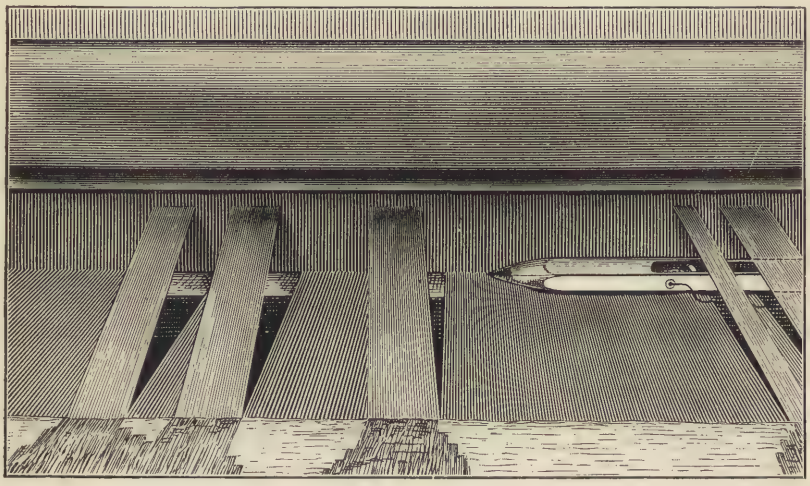


Fig. 11.

has not taken place, the upper part of the shed is wanting altogether. Fig. 12 shows clearly the weave got by a rising heald, and Fig. 13 shows the cross shedding seen from the side. This last figure shows clearly that the second heald is lowered and the sixth raised.

The cross shedding gives a double change of direction to the warp threads, so that they get a fairly severe strain. Hence it is essential for the best damasks to use only the best warp material, if the weaving is to go on without waste of time from piecing. To mitigate this evil to some extent, various means are adopted. For example, for ordinary cotton damask we do

not use healds with divided mails as shown in Fig. 14 (Plate II.), nor are the mails hung together on a single cord, with a single weight, as in Fig. 15 (Plate II.), but so many are hung on one cord as there are threads in a warp group, and each mail has its own small weight (Fig. 16, Plate II.). When, then, a thread left down by the Jacquard is lifted by a front heald, the weight hanging on the Jacquard mail will give a little, so that the thread gets less strain than in the other arrangement. Another device for lessening the strain in the cross shed is the so-called half harness shown in Fig. 17 (Plate II.). Between the stretch-

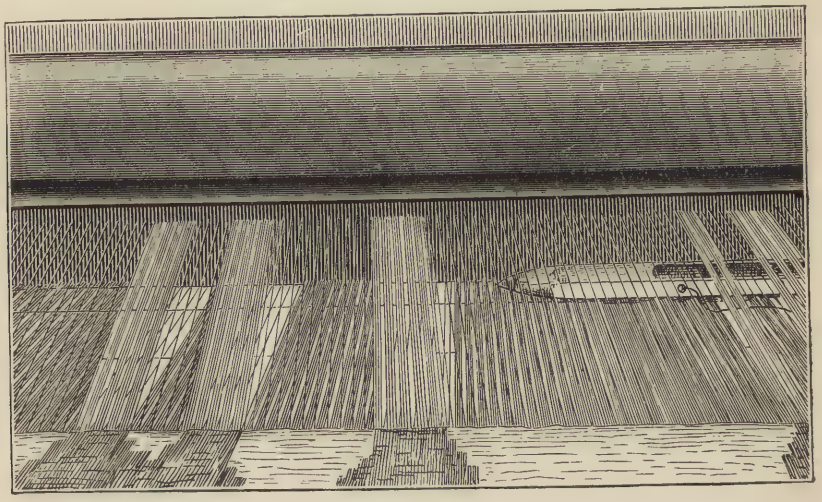


Fig. 12.

ing beam, S, B, and the Jacquard lifter there are two bars, G. The warp is put into the lifters, H, h, in the space between the bars. The mails of these are open above, and are weighted with small weights. Under the mails triangles are put through H, h, on which the lifters rest. Hence the warp threads are a little below the horizontal, between S, B and the Jacquard lifters. If, then, a strong tension is put on the warp by the cross shedding, the force is passed over to the light weights of H_1, h_1, which are in this case raised, and the tension is thus lessened.

The disadvantage of this arrangement is that in the first place the depth of the loom has to be greater, and that the work pre-

liminary to weaving is increased by having to thread the warp through H_1, h_1. But the warp is so much better preserved that much finer yarn can be used than would be otherwise possible.

The damask weaver has to pay particular attention to the proper weave, *i.e.*, to the management of the front healds. As already stated, damask is simply a complicated check pattern, so that the rules for check patterns apply. This will be clear on reference to Fig. 2 (Plate I.), where it is evident that the last thread of a square, both in weft and warp, is always the reverse

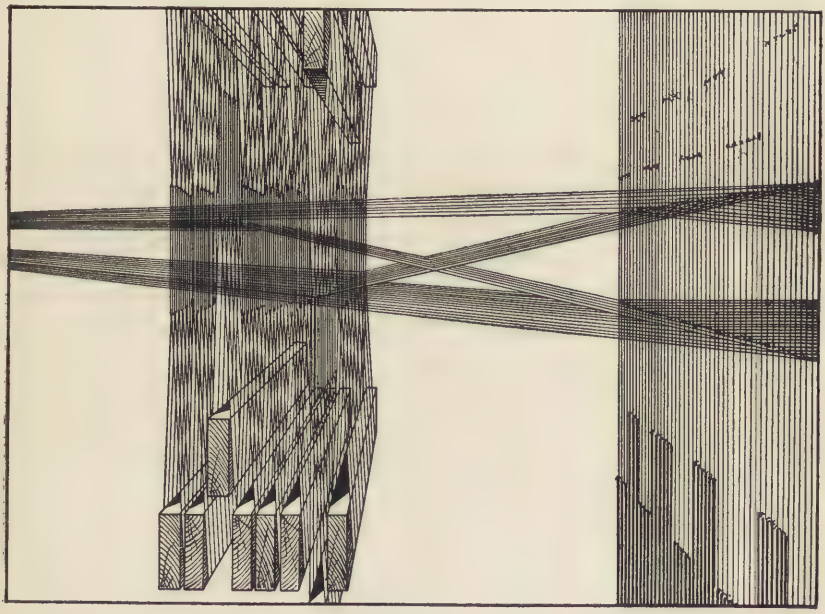


Fig. 13.

of the first thread of the next square, *i.e.*, that all points taken on the last thread are left out on the first thread of the next figure, and *vice versâ*.

This sharp crossing of the edge threads is required for a distinct rendering of the pattern, as all the threads remain exactly on the intended place, and do not pass over or under neighbouring threads. If this crossing takes place uniformly on all the four sides of the square, it is not indifferent how the weave is to be begun. To get proper crossing, atlases, for example, must be begun according to the following table:—

Weave.	Weft threads.													Warp threads.
5-leaved atlas . .	2	5	3	1	4									
6 ,, . .	2	6	4	1	3	5								
7 ,, . .	5	7	2	4	6	1	3							
8 ,, . .	6	1	4	7	2	5	8	3						
9 ,, . .	6	8	1	3	5	7	9	2	4					
10 ,, . .	7	10	3	6	9	2	5	8	1	4				
11 ,, . .	8	1	5	9	2	6	10	3	7	11	4			
12 ,, . .	10	5	12	7	2	9	4	11	6	8	1	3		
13 ,, . .	3	8	13	5	10	2	7	12	4	9	1	6	11	

The vertical columns of the table give the succession of the weft threads, while the horizontal lines give the corresponding warp threads to be lifted. For example, for five-leaved atlas, the second warp thread must be lifted for the first weft, the fifth for the second, the third for the third, the first for the fourth, and the fourth for the fifth. A proper estimate of the cross weaving is got by reading backwards so that everything that appears lowered on the last thread of the weft square is regarded as raised on the first thread of the warp square, and everything appearing raised on the last thread but one lowered on the second thread of the warp square, and so on.

Hence five-leaved atlas for damask would be managed only in the way just mentioned if the motion of the front healds would not offer an impediment. In Fig. 18 (Plate III.) there are on the left two repetitions of a five-leaved weft atlas, and on the right two of warp atlas, done in accordance with the above table. For this case there would be a set of five healds, for the cross weaving of warp and weft figures. In designing, both weaves have to be kept in view, and that with the first weft thread, the second heald must rise and the fourth fall. This is shown in the drawing by a black square for the rising heald and an open circle for the falling one. For the second weft the fifth heald must rise and the first fall. With the third weft the third heald should rise for the weft atlas, but must fall for the warp atlas. This is shown in the drawing by a cross, X. As the shaft cannot do both at once, the atlas must be managed some other way, and the sharp crossing must be abandoned. Figs. 19 and 20 (Plate III.) show possible ways of forming the five-leaved atlas. In them the

rising and falling healds give place to one another, and the crossing can only take place on one side. On the other hand, as in the six-leaved atlas shown in Fig. 21 (Plate III.), crossing is allowed on all four sides without a rising and a falling heald coming together. Fig. 22 (Plate III.) shows that seven-leaved atlas, too, with regular crossing is not usable for damask, as it would require the fourth heald to rise and fall at the same time for the fourth weft. This atlas, if wanted, must be made as shown in Fig. 23 (Plate III.), where again there is a crossing on one side only.

The cross weaving most commonly used for ordinary damasks is eight-leaved atlas, which must be managed according to the above table to get the full crossing. See Fig. 24 (Plate III.). We get the proper crossing when the warp threads are in groups of four, and the weft varies by the same gradation. The fifth thread of the weft atlas crosses exactly with the fourth of the warp atlas, both in warp and weft. This favourable condition, however, ceases as soon as the closeness of the weft has to be changed, say, when using a thicker yarn, so that only three instead of four threads enter into a Jacquard shed. Hence the matter depends on the arrangement of the heald motion. With alternate dependent heald motion the atlas points in the paper pattern will come out twill-like without alternate crossing. With independent heald motion, especially with counterpoised rising, falling and stationary healds, on the other hand, the cross weaving can be managed at pleasure.

Fig. 25 (Plate III.) is an example of the combination of two different weaves of damask, which seldom occur, and are only adduced as showing what can be done. On the whole, all weaves can be executed in damask with which the rising and falling healds can be interchanged, and in which the repetitions are either equal or exact multiples of one another.

Arrangement of an ordinary damask hand loom for a table-cloth :—

Breadth of the goods in the reed, 167 cm. without, 191 cm. with fringe. Length the same as breadth.

Machine to be used : 800 divisions.

Fig. 18.
View of Crossweaving

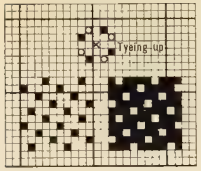


Fig. 19.
View of Crossweaving

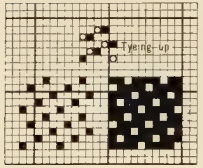


Fig. 20.
View of Crossweaving

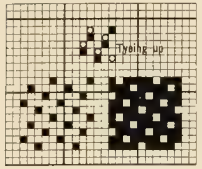


Fig. 21.
View of Crossweaving

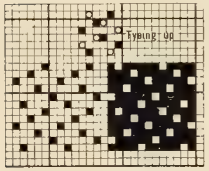


Fig. 22.
View of Crossweaving

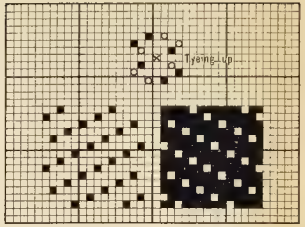


Fig. 23.
View of Crossweaving

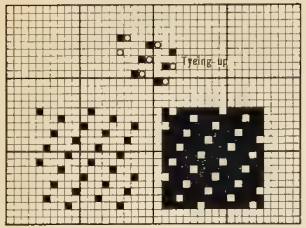


Fig. 24.
View of Crossweaving

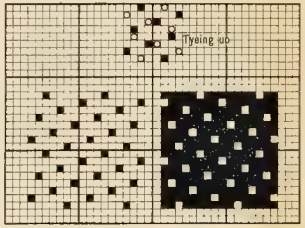


Fig. 25.
View of Crossweaving

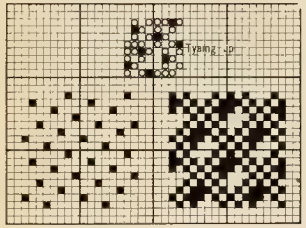


Fig. 26.

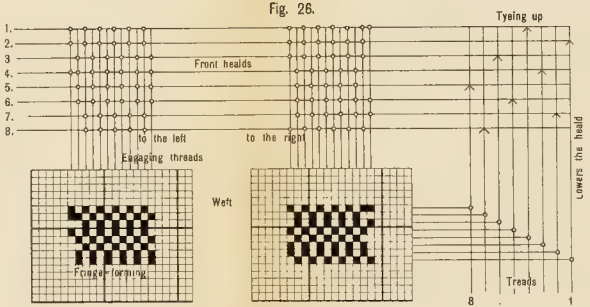


Fig. 29.

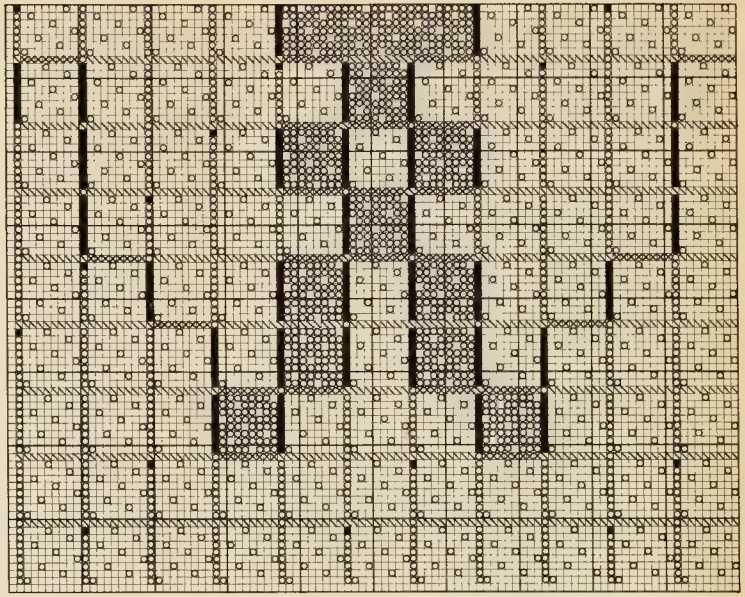


Fig. 28.

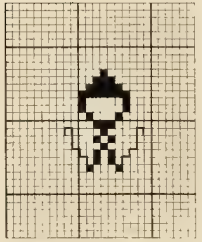


Fig. 30.

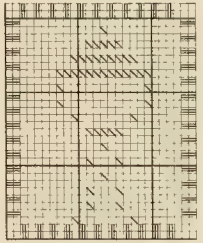
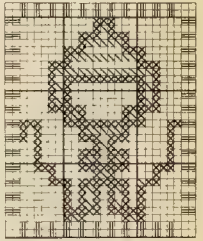


Fig. 31.



Back of
Foldout
Not Imaged

Warp material: Cotton yarn 60/2 twist.

Weft material: Linen yarn No. 50, English, fully bleached.

The closeness of the warp is forty-four threads to the cm., so that 167 × 44 = 7348 warp threads are wanted. To provide the tablecloth with fringes of weft, engaging threads must be inserted double at the sides and must be of stronger yarn than the rest, as they have to be placed in the temples and resist their pull. Of them we use twelve doubles on each side of 40/2 twist cotton. They are wound on special spools, so that their tension can be regulated independently. The machine must be fully corded so that the design may contain 880 threads. The threads are raised in fours, and each lifter receives two cords, except the 880th, which as forming the point only receives one, to avoid getting a doubled point. Thus there are altogether 1759 lifters, but as each has four mails each with a thread, there are 1759 × 4 = 7036 threads. If we compare this number with that above given for the warp (7348) we find it 312 short. The reason of this is that damask tablecovers are usually made with a smooth atlas border with the same ground cross weaving. Now, as already mentioned, on the side of the fabric uppermost in the loom all those parts of the pattern which are not lifted by the machine will show a weft effect. Hence it is unnecessary to hang on to lifters those warp threads which make the smooth border, as they have to always remain in the lower shed, and so do not require lifting. Thus the whole of the lifters can be utilised for making the pattern, and lifters can be spared on the right and left. Of these 312 border threads, 152 (nineteen sets) are threaded on the left through Jacquard mails and 160 on the right, so as to begin with a complete set. The Jacquard mails hang in groups of four. They are supported by short cords hanging merely from the comber board on knots. Thus 7348 Jacquard lifters are wanted. They are best left unvarnished, so as to be soft and yielding and cause fewer roughnesses and broken ends. The comber board will have 1837 holes distributed over a width of 169 cm., sixteen holes in a cross-row, and therefore 114 rows and thirteen holes over, or in round numbers, 116 rows. Three rows on the left take

the border threads and three on the right, while the intermediate 110 rows receive the pattern threads. After adjusting the Jacquard lifters, the warp threads are passed through them as usual. Then the front healds are put on and the warp threaded through them. If the lifters of the front healds are varnished, they must be dry, and free from knots or loose ends. Great care must be taken in threading the mails that no one is omitted or threaded double. This would cause an error in the atlas which would be very troublesome to rectify.

The following is the process :—

The first harness (the farthest back from the weaver) receives a thread from the one, three, five, etc., row in the comber board, as two warp parts always give one set in the front healds. The already often mentioned engaging threads are also threaded into the healds. They must receive a close strong weave to stand the action of the temples. To get a weave different from atlas, we can either use two special harnesses, or pass each single thread through several harnesses at the same time. Fig. 26 (Plate III.) shows this. As shown in Figs. 61-63 (Plate VIII.) the harnesses are worked with rollers, and only the sinking one is threaded, as two harnesses are always connected. Thus

at the 1st tread, harness 2 sinks, harness 6 rises.

,,	2nd	,,	7	,,	3 ,,
,,	3rd	,,	4	,,	8 ,,
,,	4th	,,	1	,,	5 ,,
,,	5th	,,	6	,,	2 ,,
,,	6th	,,	3	,,	7 ,,
,,	7th	,,	8	,,	4 ,,
,,	8th	,,	5	,,	1 ,,

The engaging threads are on the left, as shown in Fig. 26 (Plate III.), Nos. 2, 4, 6, 8, 10, 12 in harnesses 3, 4, 5 and 6; and Nos. 3, 5, 7, 9, 11 in harnesses 1, 2, 7 and 8. The first thread is put through harnesses 1, 2 and 4. On the right side the odd-numbered threads are in harnesses 1, 2, 3 and 8, the even numbers in harnesses 4, 5, 6 and 7, and the last in harnesses 1, 6 and 7.

If we follow the result of all this we find that the engaging threads weave in mixed weft ribs. If for the first weft the shuttle goes from right to left, at the second from left to right, the weft thread will not bind with the engaging thread as it finds an open shed. It will turn round to the very edge of the fabric, to prevent the last warp thread from escaping from the edge. The same thing will happen on the right side with the third and fourth weft threads. After this, however, the wefts will always find the shed closed right and left by the first engaging thread on the left, and the last on the right. Other weaves can be produced by this method, but care must be taken that the threads are not put through two harnesses which alternate for the same pick.

The weaver having depressed the Jacquard tread with his left foot, puts his right on the first harness tread. The first weft being passed, the harness pattern shed being kept open, he works harness treads two, three and four in succession. For the fifth weft he alters the pattern shed, and then moves tread No. 5, whereupon the remaining harnesses, six, seven and eight, are worked without further change in the pattern shed. The treads must be worked gently, or threads will be constantly breaking. This requires practice, and it is not every Jacquard weaver that can weave damask. The stroke of the reed takes place so as to give the ratio 1 : 1 to the outline of the figure. The shuttle used is a special one, on account of the small height of the shed, and is weighted with lead. The pirn is small and only holds a little yarn, unfortunately.

2. Damask with Figure Threads (Holbein Technique).

These damasks require two warps and two wefts. The ground warp and the ground weft make an ordinary whole damask, and on the right side of the stuff the ground becomes a warp atlas while the pattern shows a weft atlas. The characteristic embroidery-like look of the fabric (Fig. 27) is got by the union of the pattern warp with the pattern weft, as the pattern warp threads make all perpendicular outlines of the design, and the pattern weft threads all horizontal ones. The ground warp is in sections,

one section containing more threads than the rest, usually eight, which then weave with eight of the weft threads. This is done to get bolder patterns, and to imitate the angular appearance of embroidery. The pattern threads in the ground cannot form the outlines, which give the designer greater freedom in his choice of forms. In the sketch in Fig. 28 (Plate III.) the black parts show the warp pattern effect. The right side of the fabric is undermost.

Every square in the sketch consists in the fabric of eight warp

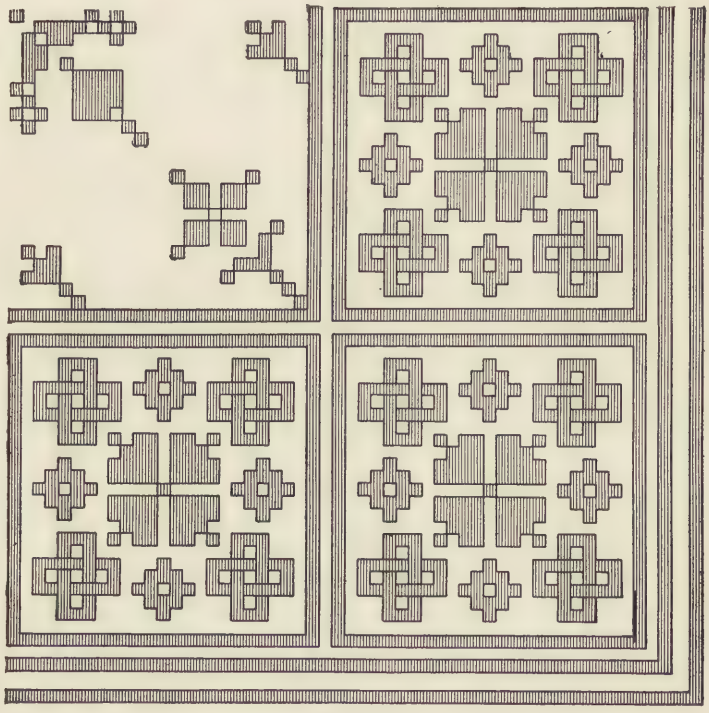


Fig. 27.

and eight weft threads, and is bordered right and left by a coloured pattern warp thread on the wrong side and by a coloured weft thread on the right side. If two or more such squares stand together so as to form a large surface, the pattern threads which would come between them, both in warp and weft, go to the lower side of the fabric, so that only the outer outline of the pattern is bordered. With long horizontal or perpendicular patterns the pattern threads weave oppositely, producing self-

colour effects if both warp and weft have the same colour. Under the large ground surfaces the pattern weft weaves with the pattern warp. This gives a light fabric united to the ground fabric to get as strong and smooth a wrong side as possible. This uniting may be done twill fashion, in which case the fourth part of the pattern warp threads are woven with a ground weft, or may be effected by uniting all the pattern warp threads by means of a special weft. In the former case one of the eight wefts is saved in each square, as the eighth is usually employed also as a binding weft, but another card is then wanted for this thread, so that the whole number of cards is increased by a third. In the second case no special card frame is required, and the eighth part of the whole ground weft is more wanted, as the binding weft on the right side of the fabric cannot be used.

Fig. 29 (Plate III.) shows the arrangement of the threads in a part of Fig. 28. The right side of the fabric is supposed to be undermost. It is clear that each square of the sketch means eight warp and eight weft threads. In the direction of the warp the first thread on the right is a pattern thread, and is followed by eight ground threads, and so on. In the direction of the weft we get, counting from below upwards, first seven ground wefts, an eighth also serving as a binding weft, while the ninth is the first pattern weft, and so on. Remembering that in Fig. 24 (Plate III.) × and ○ mean raised warp threads, and all the rest are lowered, it is easy to see the arrangement in the fabric.

In the ground, where no pattern has to be made on the right side of the goods, all the pattern threads are on the wrong side while the first seven ground wefts lie bare. At the eighth weft the second, sixth and tenth pattern threads appear, woven correspondingly to the four-leaved twill. This effects the union of the fabric. At the next pattern weft the odd-numbered pattern threads weave linen fashion, while all the ground threads are left down. The next seven wefts correspond exactly to the last, and here too a warp effect is produced on the right side, as only the eighth part of the ground warp is lifted. The pattern threads are all lifted. The following binding weft then corresponds to the first, but with

this difference, that the third, seventh and eleventh pattern threads remain down, ■, so that the twill has advanced by one thread to the right.

The eighteenth weft is the second pattern weft. If two weaves linen fashion with the even-numbered pattern threads, and with the first, second and third warp sections, all the ground threads are left down, bringing the pattern weft to the wrong side of the fabric. The pattern begins with the fourth warp section, which at this place should be already bordered on the right side of the fabric by the coloured weft. Hence with both the fourth and eighth warp sections the ground threads are represented as raised, |☒|, so that the pattern weft appears below on the right side of the fabric. With the next eight ground wefts, the fourth, fifth, eighth and tenth pattern-warp threads are in the lower shed, to border the pattern right and left on the right side. At the third pattern weft, warp sections four, five, seven and eight are raised, and warp sections three and nine at the fourth pattern weft. At the same time sections five and six remain down, although both warp parts make the figure. As here two squares in the sketch come one directly after the other, they must not be separated by a pattern weft. The close will be made above by the fifth pattern weft. The same is the case with the sixth and seventh pattern warps. These must be raised with the last eight ground weft threads of the design, so as not to separate the three contiguous squares.

The paper pattern for such a fabric is made as follows. We will first mention as an example the four-leaved connection of the pattern threads on the wrong side. The sketch is made on ruled paper, and for so many warp and weft threads as the machine has sinkers for the ground threads: here therefore half that number, for, as shown in Fig. 29 (Plate III.), a pattern sinker alternates with a ground sinker; thereby the places where pattern warp and pattern weft threads alone give the ground effect are shown by strokes (Fig. 28, Plate III.). This sketch is now filled in by first marking all the pattern threads, both warp and weft, at the edge of the paper, denoting every eight warp threads by one line, a pattern

thread alternating with a set of ground threads. In the weft a ground weft set is put first, that is, reversing the order for the warp. Then the motive is marked point by point on the unmarked ground threads, so that those pattern threads, which in the direction of the weft lie between several closely approximating points, are dotted over (Fig. 30, Plate III.). The fully drawn places in the sketch are those where weft atlas is to appear on the right side of the fabric, bordered by the pattern threads. The tendril-like ornaments running out right and left are formed by the pattern threads alone, and are not put into the paper pattern till later. To transfer the pattern any colour can be taken, such as red, ⧹.

Then all the red points so far put in are bordered with another colour, *e.g.*, carmine, ⧻, and the already mentioned tendril-like ornaments are inserted (Fig. 31, Plate III.). Then with yellow, ⊥, all pattern warp threads outside the pattern boundary are indicated. By this time the pattern has the appearance shown in Fig. 32 (Plate IV.). Next all the pattern warp and weft threads are marked for linen cross weaving, both in ground and pattern, with black, ■ (Fig. 33, Plate IV.). Finally, the four-leaved weft twill is shown with blue, ▨, on pattern threads and ground weft threads, but only the parts of them outside the pattern. These points show the connection of the pattern threads on the wrong side. The paper pattern is now ready for the cards to be perforated from it (Fig. 34, Plate IV.). Fig. 29 (Plate III.) shows clearly that for the first seven wefts only one Jacquard card is used. The pattern threads do not change their position, and the cross weaving of the ground warp is managed by the front healds. For the eighth weft a new card must be provided, as here the fourth pattern thread always appears lowered so as to unite the fabric. Hence two cards must be read off from the first weft line of the paper (Fig. 34, Plate IV.), and for the first card (seven ground wefts) yellow, blue and red must be taken. For the second card (for the eighth ground weft) yellow and red are taken, but the blue must remain lowered to unite the fabric. The same is done with all the odd-numbered weft lines of the paper. The even-numbered lines serve for only one card, the pattern weft, which weaves linen fashion with the pattern warp and must fall at

the places marked red on the lower (right) side of the fabric. Yellow and carmine are taken for these lines.

Summary: Every odd weft line receives two cards, the first denoted by yellow, blue and red, the second by yellow and red. Every even weft line receives one card, denoted by yellow and carmine.

The method of working is as follows. The Jacquard tread is established by seven wefts. For each separate weft another tread has to be taken. At the eighth weft the eighth tread makes a fresh Jacquard shed by means of the second card of the first weft line of the paper pattern. For the pattern weft a new Jacquard shed is formed by means of the third card without motion of the healds. If a special binding weft is to be indicated on the paper, we proceed exactly as above, but only one card is pierced for every weft line, using red and yellow for the ground (odd numbered) wefts, and carmine and yellow for the pattern (even) wefts. The working is distinguished in this case by the Jacquard machine remaining stationary with the ground card while eight wefts are picked. The next weft is a binding one, and for it only the eighth tread of the front healds is used, the Jacquard shed remaining closed. In this way all the pattern warp threads are united to the ground fabric, giving strength to the wrong side.

It is easy to see the difference between the two methods by examining Fig. 35 (Plate IV.). The ninth weft counting from below upwards is the connecting weft. All the pattern threads stay in the lower shed, and the eighth tread of the front healds always alone forms the shed.

The following arrangement can be used for Holbein technique.

Arrangement for hand weaving of Holbein covers :—

Width and length: 146 cm. without, 172 cm. with fringes.

Each cover square: A dozen covers.

Material: Pattern warp, cotton 20/2 twist. Ground warp, linen yarn, No. 35. Weft, the same material.

Loom arrangement: In the Jacquard the width takes $146 \times 40 = 5840$ warp threads, but of these three cm. go to left and right for the smooth border, making 6 cm. $\times$ 40 = 240 threads. Thus,

Fig. 32.

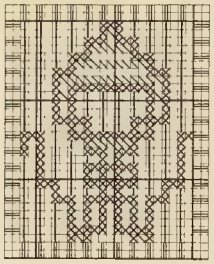


Fig. 33.

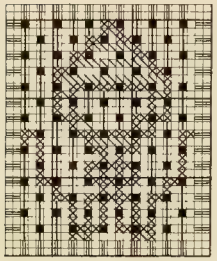


Fig. 34.

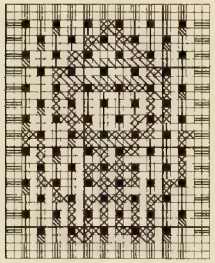


Fig. 35.

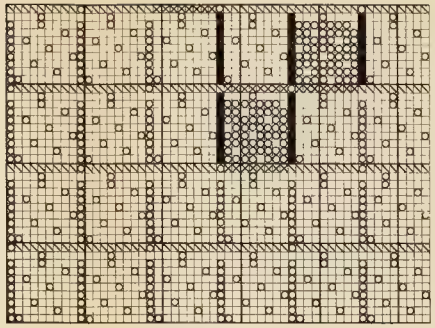


Fig. 38.

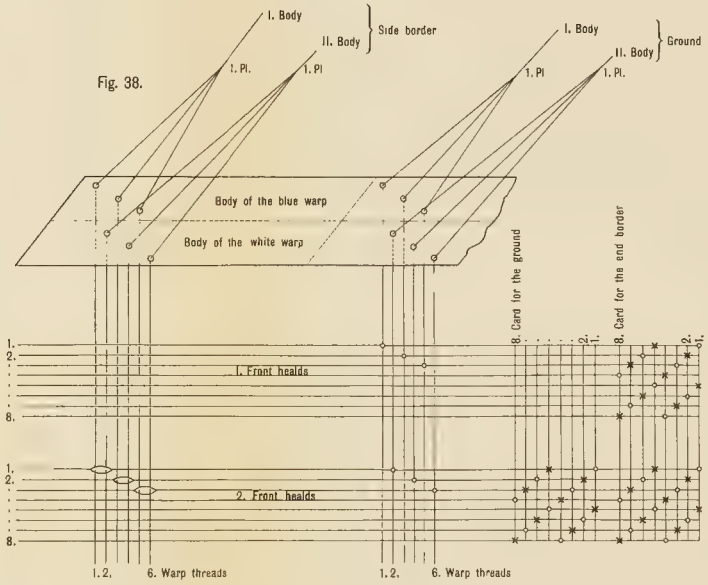


Fig. 36.

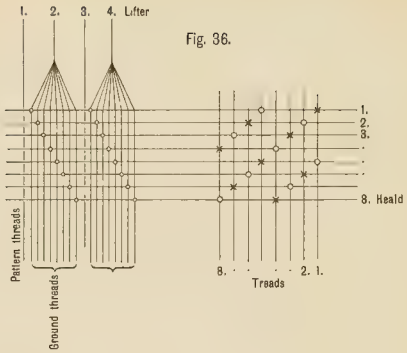
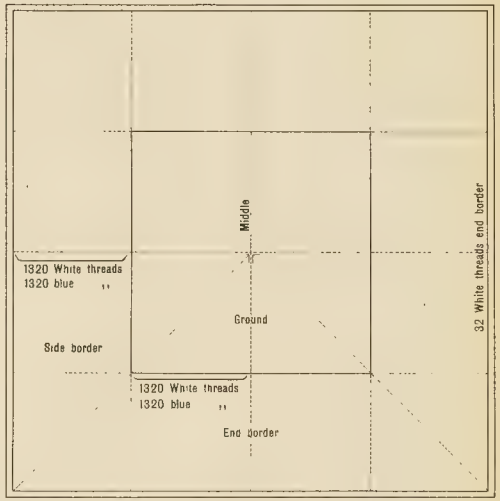


Fig. 39.



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the Jacquard machine has to move 5840 – 240 = 5600 threads. As the threads are raised in eights, 700 lifters would be necessary for working the ground warp, but this is brought down to half, *viz.*, to 350. As there is a pattern thread for every section of the warp, 350 more lifters are wanted for the pattern warp, or 700 altogether.

Comber board: 152 cm. wide, including the smooth border: 1430 holes, fourteen in a cross-row. Depth 10-11 cm.

Drawing-in: One diamond draft over the whole width.

Setting the harness: Two threads to each lifter except the 700th, of which the mail receives only one. On the odd-numbered lifters one eye is hung for the pattern threads, and on the even numbers eight eyes, or two sets of four eyes, for the ground warp.

Front healds: Eight harnesses with 730 sinkers each with long cord eyes. For the fringe threads, twelve sinkers more on each harness left and right, seventeen cm. from the border. The movement of the front healds is by rollers, as shown in Fig. 61.

Reed: 1460 dents in a width of 152 cm., twelve dents for the fringe threads, seventeen cm. from the edge.

Threading: The pattern warp through the single-eyed sinkers, and free through the front healds, the ground warp in the eight-eyed lifters of the Jacquard, and throughout single in the eight harnesses. In the reed the odd-numbered dents receive one pattern and four ground threads, the even numbers four ground threads only.

Warp: Ground warp: 5840 threads, twenty-two and a half metres long. Pattern warp: 700 threads, twenty-three metres long. Fringe threads: twelve double threads right and left, each on a separate pirn. The fringe threads are threaded, as shown in Fig. 26, into the mails of the front healds.

Weft: According to paper pattern Fig. 29 (Plate III.).

Design: The motive for these covers is sketched for 350 warp threads. The paper pattern is therefore arranged on 700. First warp thread a pattern thread, second warp thread a ground thread; *vice versâ* with the weft. Reading and working from the design as in Fig. 29 (Plate III.) and Fig. 34 (Plate IV.).

3. Double Damask.

This means a technique very effective with fine heavy linen damasks. (See Fig. 37.)

Fig. 37.

The fabric is two-coloured in the borders and one-coloured in the ground. Both colours enter into the warp, but the weft is single coloured. Tablecloths and napkins made by this method

have no wrong side. One side shows a blue pattern on a white ground in the borders, the other a white pattern on a blue ground. The weft is entirely concealed in the middle, and is used for pattern making in the ground only.

Fig. 38 (Plate IV.) shows the arrangement for weaving, lifting the threads in threes. The following will make the whole arrangement clear.

Arrangement for a tablecloth, double damask :—

Breadth and length, 120 × 120 cm.

Material : warp, bleached linen yarn, No. 10, and blue, No. 70 ; weft, bleached linen yarn, No. 80.

Machine : 1600-hook Lecasse with 1760 lifters.

The threads are lifted in threes, and in the weft two and three are to be picked in turn. The warp consists of eighty-nine threads white in two cm. and eighty-nine blue, the weft of thirty-seven threads to the cm. Fig. 39 (Plate IV.) shows the division of the sketch for the paper pattern. For each of the two long edges 1320 white and 1320 blue threads are allowed, 2640 altogether. Hence there are $2640 \div 3 = 880$ lifters required. This is reckoning half the width of the fabric, so that 1760 are wanted in all. The cloth has also to be provided with a narrow smooth edge all round, for which thirty-two threads are allotted, which however want no lifters, but are simply threaded into the eyes hanging from the comber board.

Fifteen cm. from the smooth border, forty-eight threads are to be taken for fringe, which are wound on special pirns. The blue warp acts in both borders through the length of the cloth, and in the middle of it only in the side borders, and lies below in the ground bare, *i.e.*, without cross weaving, to be cut out afterwards. Hence they must be worked differently, and two beams must be used, one for the length borders, and the other for the ground. Hence three warps have to be arranged, a white one of 5344 threads for the whole width, a blue border warp with 2640 threads, and a blue ground warp with 2640 threads.

As appears from the division of the sketch the design is sym-

metrical, so that the threading will be simple in point and double harness.

In drawing in the warp threads the thirty-two white threads are first put through the mails, and then a blue thread in the first mail of the first harness, and a white one in the first mail of the second harness. Also four blue and four white threads go together per reed dent.

As here a thread of the first harness always alternates with one of the second, there is no use in hanging several eyes on one lifter, so that one only is used, and three cords go from each lifter for each harness. In setting the harness, lifters 1-880 receive each six cords for the first harness, and Nos. 881-1760 each six for the second harness, each cord holding one mail and one thread.

The comber board must therefore have 10,560 + 64 = 10,624 holes in twenty-four rows, the back twelve rows for the first harness, the front twelve for the second.

In drawing the paper pattern the process is as for simple damask, except that here figures standing in the ground and hence not involving the blue warp, but made of weft and white warp, have to be marked with a different colour from those in the borders. Supposing the figures in the borders to be marked red and those in the ground blue, we have the following reading :—

First harness (blue warp) indicated by red, as it makes the border figures.

Second harness indicated by white, as the whole ground is formed by the white warp.

The blue-indicated figures in the ground will thus be shown to be formed of white weft on the warp ground.

In the long edges, therefore, figure and ground are produced uniformly by both warps, which can therefore be worked by the same front healds. In the ground, on the other hand, this co-operation only exists in the short edges, and in the middle the blue warp must remain on the wrong side. Hence the two warps must be raised independently, and another front heald is wanted to take the blue warp only. See Fig. 38 (Plate IV.).

In the short edges both sets of healds are worked, but only the

second in the ground. Hence two different threadings and two sets of treads must be used, the first set to weave the short edges, the second to weave the middle. If the front healds are moved by a machine, another card must be hung on after each short edge.

After drawing the threads of each warp through the mails of its own harness they are threaded into the front healds. In the two long edges a blue thread from the first harness and a white one from the second are passed together through each mail of the second front heald. Thus, in the above example, we have at first 1320 mails on the left, each with a blue and a white thread. From here each thread has a mail to itself, the blue threads in the first or hinder, the white ones in the second or foremost front harness. Hence there will be 2640 mails in each harness. Then follows the second long edge with 1320 double-threaded mails in the second front harness.

Hence the hinder set of healds is narrower, only bearing mails over the width of the ground, while the front set is as wide as the comber board and bears eyes uniformly distributed over the whole space. Harnesses one to eight in the hind set thus bear 330 mails, but harnesses one to eight in the second set bear 660, each mail six to seven cm. long.

Fig. 38 (Plate IV.) shows the arrangement of the loom clearly. In weaving the short edges the two sets of healds work together, but, as shown by the cards, only the front set is used for the middle of the cloth.

CHAPTER III.

DAMASKS WITH GROUND AND BINDING WARP THREADS.

Fabrics in this group differ from ordinary whole damask by showing alterations of outline, several threads at a time, in the warp but not in the weft.

There are usually at least two different weft layers, a binding weft and a pattern weft. The proportion between the two depends on the quality of the goods. With unicoloured furniture damasks, with a single weft colour, a pattern weft thread and a binding weft thread usually alternate. With many-coloured goods a binding weft comes after each coloured set. These goods have also two warps, a ground warp and a binding warp, which usually alternate thread by thread. Also after each warp section, or in some cases after each half-section, or even in close silk damasks after each pair of warp sections, comes a binding thread, to unite the figure wefts on the two sides of the fabric. The ground warp is less suitable for this, as one binding point would take in an entire warp section. The already mentioned close silk goods form an exception. In them the ground warp can also be used, and thus a greater variety of effects may be secured.

1. Furniture Damasks.

These can be divided into three classes :—

1. Those in which the ground warp forms a smooth atlas, on which appear one or many-threaded weft figures. These figures are in this case bound by the binding warp. They also show a perfectly smooth surface, and the warp binds both sides of the fabric.

2. Those in which the ground warp forms a smooth atlas, but

in which the weft figures are bound in ribs on the right side of the fabric by the binding warp, after the fashion of Gobelin fabrics, and bound in any desired fashion on the wrong side. As these goods are usually made of several colours, and the figure weft is generally of stronger material, a comparatively large amount of weft goes to the underside of the fabric, and therefore the binding warp is much more woven in than on the right side. Hence two binding warps are needed, one kept exclusively to the upper side, while the other does the binding on the under side.

3. Those in which the many-coloured design appears to be executed, so that too long bare stretches of weft on the right side are avoided. Hence a cross weaving of the weft figures is superfluous, and with silk goods of moderate closeness we get very fine and pure colour effects.

2. Furniture Damasks with Atlas Weaving in the Warp and a Twill Weft Figure.

The binding weft is intended to connect the ground warp threads, usually in atlas, and is usually taken of the same colour as the ground warp, to prevent the interference of other colours. Thus the many-coloured figure weft only weaves with the ground warp as required by the design, *i.e.*, the ground warp threads are raised according to the paper pattern. At the same time, a part of the binding warp is brought into the upper shed, and in this way the combination of the upper side of the fabric with weft effect is secured.

Fig. 40 (Plate V.) illustrates this. The sign ○ means the ground warp threads, ● is the section of the binding warp threads. In the left-hand part of Fig. 21 ground threads, *i.e.*, seven lots of three warp threads, are lifted, while in the right-hand part seven lots of three warp threads remain down. Thus the pattern weft on the left half of the design will be on the under side of the fabric, and that on the right half on the upper side. Of the threads denoted by ●, Nos. 3, 6, 9 and 12 are in the upper shed, so that on the right it will bind the pattern weft in three-leaved twill on the upper side, and on the wrong side on the left.

The following shedding is required for the weft: The ground warp must weave eight-leaved atlas on the upper side, so that seven-eighths of the ground threads are in the upper shed and one-eighth in the lower shed. The binding warp remains as with figure weft, binding and figure weft coming in the same shed with the binding warp. Now as the ground warp forms an atlas, the weaving is made much more difficult, if the right side of the fabric is uppermost, so that we with very few exceptions weave with the wrong side uppermost. Fig. 41 (Plate V.) shows that the ground warp is lifted over the whole breadth of the fabric for the binding weft in eight-leaved atlas. Hence no Jacquard card is wanted for this shed, and the ground threads are passed not only into the mails of the Jacquard but into those of a front harness. Figs. 40 and 41 (Plate V.) show that the binding warp works by itself in three-leaved weft twill, so that it can be worked by the front healds with extra lifters. There will be only one harness and two front sets of healds, the front one of them with three shafts for the binding warp, the other with eight shafts for the ground warp.

Fig. 42 (Plate V.) shows the drawing in. The lifting being three threads at a time, the first three to the left are ground threads, lifted by lifter No. 1. After these three threads have passed the Jacquard, they are passed separately through the first three shafts of the hindmost front harness. The fourth thread is a binding thread, which is not threaded through any pattern mail, but only in the first mail of the first binding harness. Then again we have three ground threads in shafts 4, 5 and 6, and then a binding thread in the first mail of the second binding harness, etc. It is clear that threads of many different colours may be used. All these coloured wefts come into the same shed of the binding warp (Fig. 40, Plate V.). On the other hand, a fresh Jacquard weft must be made for each figure weft, because each colour has to appear at another part of the fabric.

As already said, the closer weaving of both warps is only a matter of healds, so that no heed need be taken of it by the designer, who can make his drawing with colours without any binding points.

The pattern paper is made out according to the number of

Fig. 40.
Section

Fig. 41.
Section

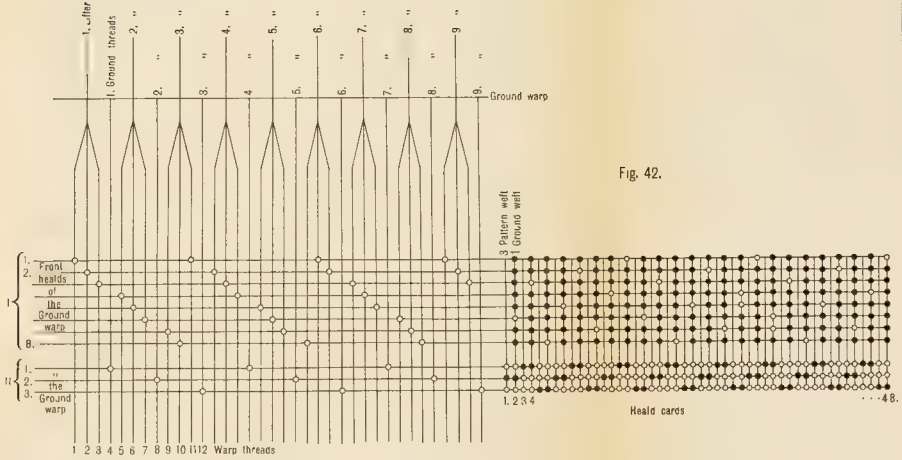


Fig. 42.

Fig. 43.

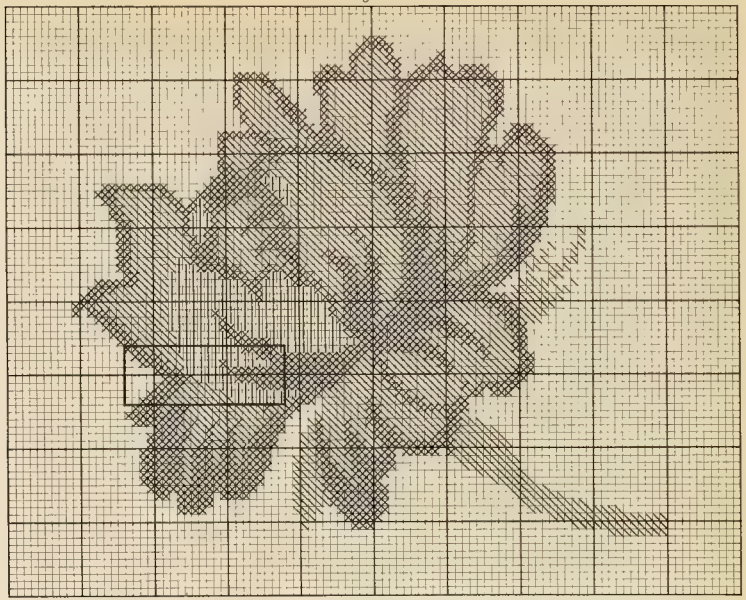
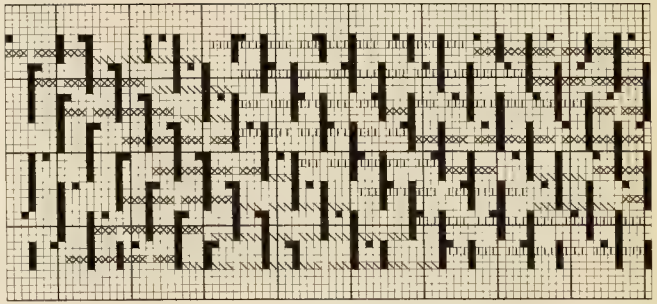


Fig. 44.
View of
Crossweaving



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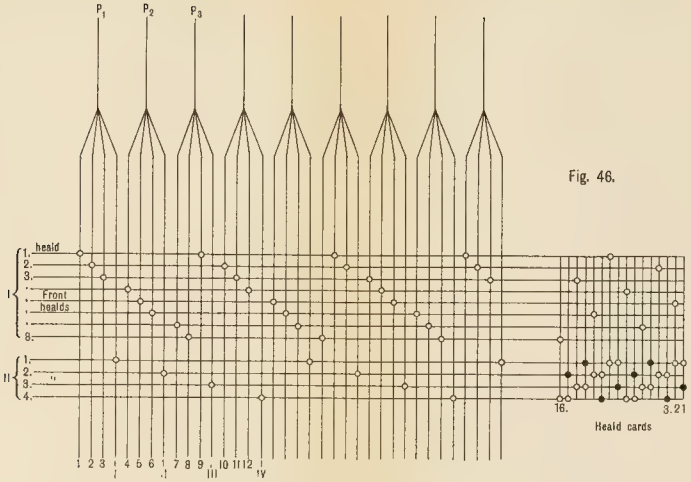


Fig. 46.

Fig. 45. Section

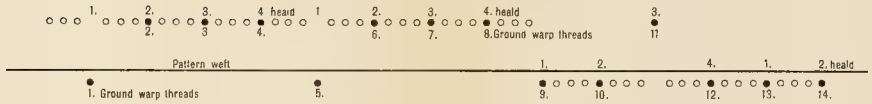
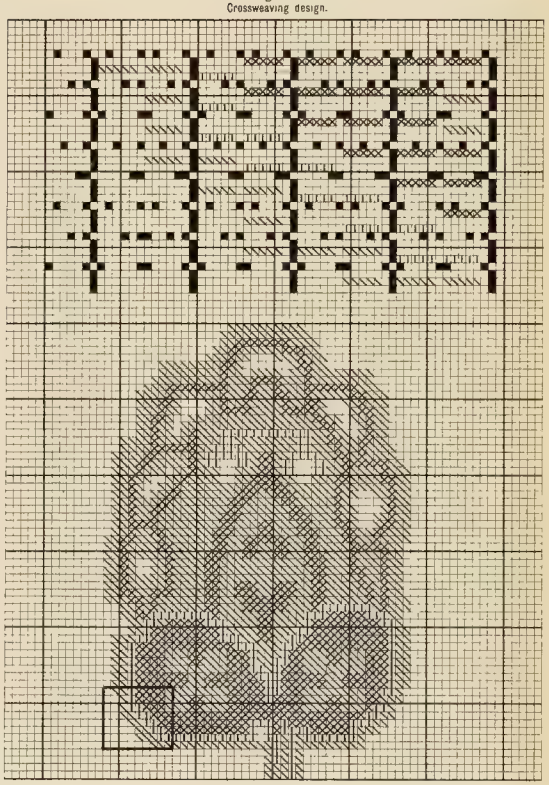


Fig. 47. Section

Fig. 48.
Pattern

Fig. 49.
Crossweaving design.



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warp sections and of pattern weft threads of one colour in the same space. Fig. 43 (Plate V.) shows a part of the pattern for such a fabric. All empty spaces, □, mean eight-leaved warp atlas, in which one warp line in the drawing means three threads in the fabric. There are three weft threads, denoted by red, yellow and carmine. These pattern wefts must be weaved with the binding warp in three-leaved twill, as shown in Fig. 40 (Plate V.). This gives the following card reading. Each weft line receives three cards (another card for each colour). For the first card read red, ⧵; for the second, carmine, ⧻; for the third, yellow, ||. The cards are marked 1, 1*a* and 1*b*, and put one behind the other. Here the right side of the fabric comes below in the loom, and the following is the course of the weaving. First weft, red: the griffe is raised and that of the shaft machine which works the front healds. But only the second front harness is raised, so that one harness remains in the lower shed. Second weft, brown: the shed of the shaft machine remains open, and a fresh shed is made by the Jacquard. Third weft, yellow: as with the second. Fourth weft, binding weft, requiring no Jacquard shed but a fresh shed from the healds, made by the rising of one ground warp and two binding warp harnesses, the two which with the three previous figure wefts were already in the upper shed.

If high warp harnesses are in use the cards are perforated as shown in Fig. 42 (Plate V.). The odd-numbered cards belong to the figure weft, the even numbers to the binding weft.

As in this example the ground warp is woven in eight-leaved atlas and the binding warp in three-leaved twill, $8 \times 3 = 24$ cards must be perforated for the shaft machine, and twenty-four more for the ground weft, forty-eight altogether. In Fig. 42 (Plate V.) the sign ○ means perforated places, the sign ● unperforated places.

Fig. 44 (Plate V.) shows the weaving of the fabric, thread following upon thread both in warp and weft, as they have their positions in the fabric. All empty spaces mean lowered threads in both warps, the others being raised.

In Fig. 44 (Plate V.) the fabric is shown as it really is in the loom, right side under. The order of the warp threads corre-

sponds exactly to that shown in Fig. 42 (Plate V.). A binding thread follows every three ground threads, and a binding weft after every three-coloured figure wefts. In the first six warp sections, *i.e.*, ground threads one to eighteen, the first red weft is on the wrong side of the fabric, so that the six sections have to remain in the lower shed. With warp sections seven to fifteen the red weft has to appear on the right side, so that, that side being uppermost, those sections have to form the upper part of the shed, and must be lifted by the Jacquard. This lifting corresponds exactly to the reading, in which the first card is taken red. The binding warp sees to the cross weaving. In it, corresponding to card No. 1, Fig. 42 (Plate V.), healds one and three form the upper shed, and No. 2 the lower shed to bind the right side of the fabric.

The following weft from below upwards is brown. It forms the pattern in conjunction with warp sections three, four, five and six, so that these are lifted, corresponding to the reading for the second card shown by carmine. The binding threads are the same, so that the shed of the healds is not changed. The third figure weft (yellow) patterns with the warp sections sixteen to twenty-two, which must therefore be raised. The following weft is a binding weft, so that the Jacquard machine remains still, and only the healds make a shed. The first and third binding harnesses rise, and the sixth ground warp harness, to weave on atlas. Here then we have four wefts alternating, Fig. 44 (Plate V.), as shown by the single weft line in the paper pattern.

As while the binding weft is being picked the Jacquard eyes remain in the lower shed, while however a part of the ground warp is lifted by the front healds, we get a half cross shed. That the lifters one to eight in Fig. 42 (Plate V.) must have long mails need not be further insisted on, but the binding healds may have cord or metal eyes.

Fabrics in which the Figure Weft is bound on both sides for Weft Effects.

Figs. 40, 41 and 44 (Plate V.) show that the wrong side of the fabric shows a three-leaved warp twill effect in the binding warp,

but in such goods it also often happens that the figure wefts show effects on the wrong side as well as on the right side. Fig. 45 (Plate V.) shows a figure weft shed, right side under.

The ground threads, ○, are in lots of three warp threads, and every warp section is followed by a binding thread, ●. The former are raised in masses by the Jacquards. The latter bind the figure weft on both sides of the fabric in four-leaved weft twill. Fig. 45 (Plate V.) shows that the binding warp shows in the upper shed the warp side of the four-leaved twill with warp sections one to nine, and the weft side of the twill in sections ten to fourteen. Thus the weave structure is not the same over the whole width of the fabric, like as in Figs. 40 and 41 (Plate V.), but changes according to the pattern and the warp or weft side of the twill. If here, too, the binding warp is put through harnesses one, two, three and four, we must, according to Fig. 45 (Plate V.), beginning on the left, lower the first binding harness and raise the other three.

If, for example, we follow the position of the binding warp towards the right we find that threads two, three and four are in the upper shed, and are threaded in the corresponding harnesses. The fifth thread goes into the second mail of the first harness, and goes with it into the lower shed. Threads six to eight are in the upper shed, and pass into the second mail of harnesses two, three and four. The ninth thread is in the lower shed and is threaded into the third mail of the first falling harness. So far therefore the order is unchanged, as every thread to be lifted is in the eye of a rising heald, and *vice versâ*. With the tenth thread, however, it is different. This is in the third mail of the second harness, which brings it into the upper shed, and the same is the case with the twelfth thread in the third mail of the fourth harness. Here, therefore, the binding threads are no longer moved by a definite number of healds, but require a special movement, which is given by means of another Jacquard harness. In this case the Jacquard has to be doubled in size, but at the same time more variety of pattern can be produced. If this, however, is not wanted, but merely a smooth weft effect on both sides, the fabric can be made

with a single harness, when the weave of the two sides is managed as follows.

Fig. 46 (Plate VI.) shows the warping and also the cards for the Jacquard. A binding thread follows every warp section of three ground threads. The ground threads are passed as shown in Fig. 42 (Plate V.), first through the Jacquard mails, and then singly into the long mails of a front harness. But the binding threads are different here from what is shown in the figure. They are not taken freely through the Jacquard and threaded in the eyes of the front harness only, but they go through the mails of both. They can either receive a separate mail although hanging from the same cords as the ground thread mails, or they may be threaded above the eyes between the two upper parts of a several-threaded pattern mail, so as to be always lifted. Hence the first lifter moves the first warp section and also the first binding thread. In Fig. 46 (Plate VI.) the ground threads are marked with Arabic, the binding threads with Roman numerals. The second lifter moves the second warp section and its associated binding thread, and so on. In Fig. 42 (Plate V.) the front harness for the binding warp has ordinary metal mails six-seven cm. long, so as not to hinder the lifting of the binding threads. The motion for the binding harness must be arranged for rising, sinking and pause, and there will be cross shedding. For the sake of simplicity the Jacquard mails are left out in Fig. 42 (Plate V.), only the other being shown. Fig. 47 (Plate VI.) will help to illustrate the matter. It shows the thread for a figure weft. Warp sections one to seven are in the upper shed with their binding threads, and warp sections eight to fourteen with theirs in the lower shed. Thus the figure weft in the first left-hand side of the shed would be without weave below, and on the right-hand side without weave above. To bring cross weaving into the shed, binding threads must be brought down into the lower shed in the first half of the shed and up from the lower shed in the second half. This is achieved by means of the front binding warp harnesses, as shown in Fig. 46 (Plate VI.). With the first card then the first binding thread goes into the upper shed and the third into the lower shed, so that the binding threads marked with I. in

the second (right hand) side of the shed are raised and there bind the figure weft. As the third harness is lowered all the upper shed binding threads marked III. are brought down into the lower shed and make the binding there. As many wefts are picked into the binding warp shed as there are different colours. The even-numbered cards up to No. 16 form the shed for the binding weft, for which, corresponding to the ground weaving, a ground warp harness and a binding warp harness are raised.

With the already mentioned many-coloured goods, which are designed so as to avoid too long bare spaces of weft on the right side of the fabric, so that no cross weaving is needed, only the wrong side is made in linen, so that threads are brought from the lower to the upper shed, but never *vice versâ*. Here then the Jacquard can only be arranged for high warp, and the linen weaving is perforated on the card for the second front harness.

3. Furniture Damasks with Gobelin Weaving of the Weft Figure.

As already stated, these require three warps, a ground warp and two binding warps, one for the right side, the other for the wrong side of the fabric. All three are usually so managed that after each warp section comes a binding thread for the right side and one for the wrong side. In special cases in the second binding warp there is only one binding thread for the right side after every two warp sections. On the right side of the fabric the ground warp weaves in the same manner as already described, in warp atlas, or some other open cross weaving without binding weft. The figure wefts are bound by the upper binding warp, as when they are picked the whole of that warp is in the upper shed. The lower binding warp is either left down all the time, or is partially raised, according to the particular weaving of the wrong side. As the pattern is formed by the ground warp the two warps exchange positions. What has now been said, however, is true only when the right side is uppermost. As it is under in weaving, the truth is the reverse.

Fig. 48 (Plate VI.) is a part of a paper pattern for such a fabric.

The empty spaces round the pattern mean a five-leaved atlas ground with the usual colour signs for the figure wefts. The warp sections are of five threads. After each warp section there is a binding thread for the upper side, and after every two sections one for the lower side. The ground warp is put through the Jacquard mails and the long mails of five front harnesses. The binding warp for the right side goes through the mails of the sixth harness. If the mails are put closely, they may be put through two or four harnesses. As the three colours in Fig. 48 (Plate VI.) mean weft, the reading for the right side of the fabric is very simple. For the first card we read yellow; for the second, red; for the third, carmine.

From the weave shown in Fig. 48 (Plate VI.) we see that the ground warp makes a five-leaved atlas with the binding weft, and that a binding weft thread follows each lot of three-figure wefts.

The weaving of the figure wefts on the right side of the fabric is done with one warp, which then remains in the lower shed, being raised for binding weft only (all white spaces mean lower shed warps). The wrong side is woven with the second warp, which rises when figure wefts are picked and is down for binding wefts only. Hence the weaving of the wrong side is a little too close, so that we can hardly proceed in this way with fabrics with thick figure wefts. It is then better only to place half the binding threads of the second warp over the figure wefts on the wrong side, so that the shed corresponds to Fig. 50 (Plate VII.).

In this case the lower binding warp is again threaded through the Jacquard mails, and the arrangement is that of Fig. 46 (Plate VI.). This binding warp is then put through two harnesses with long eyes, one of the two always rising as the figure weft is picked.

In Fig. 50 (Plate VII.) ○ denotes ground threads, the binding threads for the wrong side of the fabric, and ● the binding threads for the other side. In the left-hand part of the shed warp sections one to five are lifted together with their binding threads. The first binding warp, ⊙, weaves with the figure weft, while the second

binding warp acts in the right half of the shed, and of it all even-numbered threads are lifted by the same harness. This shed remains open for all the wefts denoted by the same line in the design. With the binding weft the second binding warp has the same shed position as with the previous figure weft, and is again raised linen woven, the first binding warp now remaining entirely in the upper shed. This is repeated for each section, with the difference, however, that now with the figure wefts the other harness with the odd-numbered warps is raised.

Fig. 51 (Plate VII.) shows another variation of this method. The warp is in sections of five threads, with a binding thread for each side after each. The ground warp is woven in three-leaved twill, two wefts to a shed. The weaving of the right side is done according to Figs. 49 (Plate VI.) and 50 (Plate VII.), the wrong side still appearing with linen weaving, although now it is only the binding weft which weaves so with the second binding warp. At all figure wefts the second binding warp is raised, but at binding wefts only half of it goes to the upper shed. Another variation is shown in Fig. 52 (Plate VII.), where the warp threads are in sections of six, three ground threads first, then a binding thread to the wrong side for the second warp, then three more ground threads and then another binding thread, this time for the right side.

There are also three figure wefts and three binding wefts, while Fig. 51 shows one only. These binding wefts are woven with the ground warp to a five-leaved atlas. The second warp weaves linen fashion with the figure wefts, and at the same time lies bare over the two following binding wefts, so that it is raised for five wefts, and lowered for seven.

4. Broché Furniture Damasks for Sofas and Hassocks.

These require the same arrangement as shown in Fig. 50 (Plate VII.). The lower binding warp is threaded as shown in Fig. 46 (Plate VI.), *i.e.*, in a mail of the same heald which moves the corresponding warp section, and then also through the mails of a front harness. The binding warp for the upper side passes between the Jacquard eyes and is threaded through those of a

separate harness. The weft is also arranged like Fig. 46, except that a second is added to correspond to the number of threads in a warp section, including their companion binding thread.

Besides the coloured figure weft threads wefts of other colours are also used for the broché effect. These extra threads are only visible in parts of the pattern, and in the width of the stuff lie mostly on the wrong side. To save material and to prevent the fabric from becoming too close, the broché threads are woven in only enough to give the necessary strength to the pattern, so that they are not bare over the whole width of the fabric. In this case as many broché shuttles are wanted as there are figure places of the same colour in the width of the goods, and each of those shuttles is picked by hand, and not by the usual mechanical contrivance. Thus, for example, in a width of 120 cm. there may be three repeats of ground, in each of which a distance of about two cm. has to be brochéd with red weft. Three broché shuttles of the same colour to a weft line would lay in six to seven cm. of weft, while that line with continuous picking would mean a length of thread equal to the width of the reed, *i.e.*, more than 120 cm. If this red weft is to figure on the right side of the fabric at two places, separated by ground, it would have to lie bare on the wrong side between those places, where it would have to be cut out afterwards.

The broché threads are not taken into account in making the paper pattern, but only the warp sections and the number of continuous coloured wefts for the same space, and so the calculation of the paper pattern is worked out. But every broché thread must have its own Jacquard card.

The shedding of the continuous figure weft corresponds to Fig. 50 (Plate VII.), with the difference that the weave of the wrong side is usually twill, as there is always a larger number of different weft threads. With the right side of the fabric below, the following is the shedding for the broché threads, as shown in Fig. 53 (Plate VII.). The broché weft must form pattern in the left hand of the shed. Hence the warp sections one to five are lifted with their binding threads, and only the threads of the first binding warp are lowered.

Fig. 50. Section

Fig. 51.
View of Crossweaving

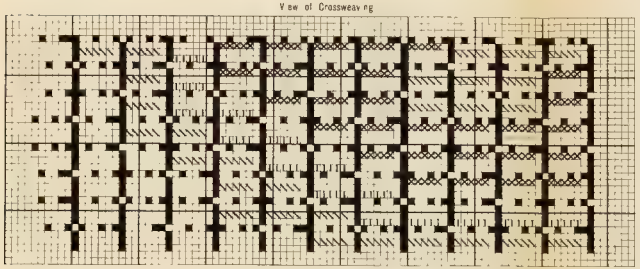


Fig. 52.
View of Crossweaving

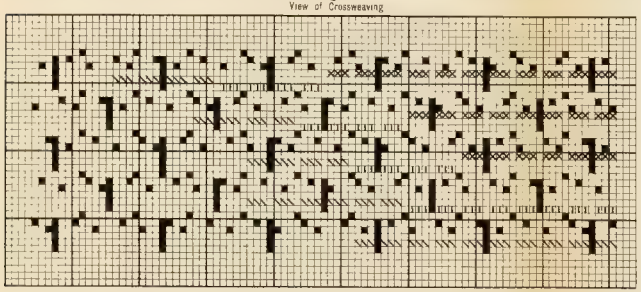


Fig. 53. Section

Fig. 54.
Pattern

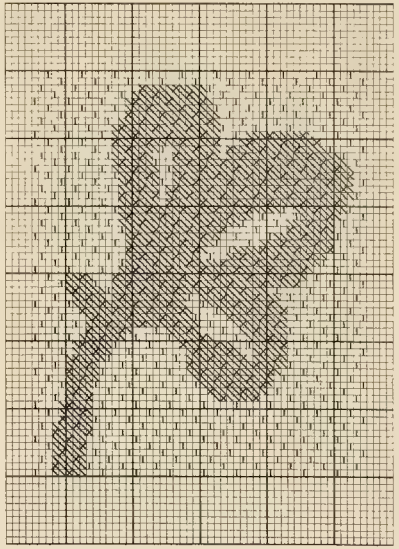
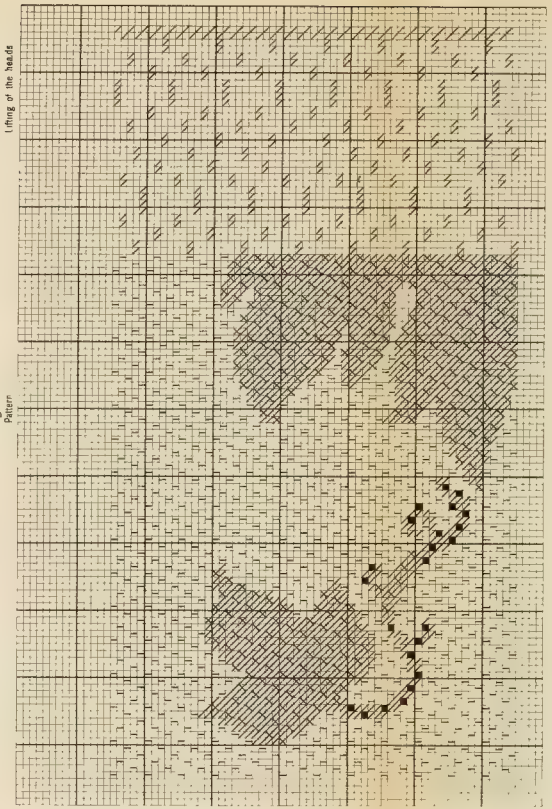


Fig. 55.
Pattern



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In the right half of the shed the ground threads remain down, so that the binding threads cannot be lifted, and the broché weft remains without any weaving above.

For one continuous ground weft as shown in Fig. 50 (Plate VII.) the Jacquard and the harnesses lift together, but the broché weft is worked by the Jacquard alone, the harnesses then remaining motionless, as that weft requires no weaving on the wrong side of the fabric. Finally, the binding weft is worked by the harnesses alone, the Jacquard remaining stationary.

5. Double Harness Furniture Damask.

Simple and useful as the above arrangements are, in which both ground and binding warp are passed into the front harnesses, cases occur in practice in which it is desirable to work the two warps independently, so that each thread can be moved separately. This can be done by having a second harness on the Jacquard for the binding warp, whereby the number of lifters is certainly much increased, but on the other hand the inconvenience of cross shedding in the binding warp is avoided. The arrangement will also give weaving effects which are unattainable with front harnesses. A furniture damask requiring 400 lifters when the former method is used will require 800 with a double harness. The warp is threaded through the Jacquard mails of the second harness.

As now the binding point must be denoted, the paper pattern has to be changed. For smooth unicoloured furniture damask, the paper pattern is made as shown in Fig. 54 (Plate VII.). The drawing is made with any colour, say red, on the ruled paper, leaving the ground at first blank.

The pattern is to be formed by the weft, which is woven into a five-leaved atlas by the threads from the second harness. This weave must be indicated by another colour, say carmine on the figure, and yellow on the ground. The right side being under in the loom we have the following reading. Each weft line receives two cards: for the first card (figure weft) and for the first harness, red and carmine; for the second harness, red and yellow; for the

second card (binding weft), no colour for the first harness and yellow and red for the second.

The ground warp must here too be threaded through the Jacquard mails and long eyes in a front harness, which can be worked either with counterpoises or by a harness motion, or direct by the lifters of the Jacquard. In the last case, the weaving for the front harness is indicated in the paper pattern, as shown in Fig. 55 (Plate VII.). Several lifters are taken for each harness, but not contiguous ones, but so arranged that for the first side of the harness a few lifters are indicated at the beginning of a cross row, and on the left side the last lifters of the same row. For example, a harness of 300 lifters would be taken, requiring a 600 machine, having twelve lifters in a cross row. If the ground binding is to be eight-leaved atlas, eight harnesses will be wanted, to be raised by the lifters of the harness.

Six hundred lifters for the pattern are in fifty rows, so that $5 \times 12 = 60$ are available for moving the healds. If we reckon six lifters per harness, we have $6 \times 8 = 48$ lifters, or rows fifty-one to fifty-four. In this case then for the first harness on the right-hand side, the three first lifters of the fifty-first row are used, and the last three on the left side. For the second harness, the middle six lifters of the same row are used. For the third and fourth harnesses, the fifty-second row of lifters is used in the same way, the fifty-third for the fifth and sixth, and the fifty-fourth for the seventh and eighth. For the paper pattern 300 warp lines are to be reckoned for the figure, and then forty-eight lines have to be drawn for the heald raising, as has been mentioned in connection with Fig. 55 (Plate VII.).

With furniture stuffs with gobelin weaving of the figure weft, the upper binding warp, with the double harness, is threaded through the mails of the second harness, and the lower binding warp in one or two harnesses, according to the closeness of the warp and the weaving on the wrong side of the fabric. For example, for linen weave there must be two harnesses, but if all the threads bind at the same time, one harness is enough.

As in weaving, the right side is below; those warp sections

where the weft is to show on the right side are lifted by the first harness when a figure weft is being picked. At the same places all the threads of the second harness are raised which have nothing to do with the figure weft, all the threads which have are left down. On the other hand, the second binding warp must be lifted entire, first to keep it away from the pattern, and secondly to bind the wrong side.

This process is repeated as often as different colours occur in the figure weft for the same line on the paper pattern. After every series comes a binding thread, at which the ground warp weaves in weft atlas. The process is somewhat different if the wrong side is to be bound taffeta fashion by only a part of the threads. In shedding for the figure weft the ground and first binding warps rise, *i.e.*, the first and second harnesses, as before. Only half the second binding warp must go into the upper shed, the other half remaining down over the whole width, and so also at those places where the figure weft is not to be bound on the right side. To remedy this inconvenience, the loom is arranged as shown in Fig. 46 (Plate VII.). The lifters of the first harness raise not only the warp sections but also the accompanying threads of the second binding warp. Thus these threads are removed from those parts of the right side where the figure weft is to appear, while the other weave in taffeta by alternate rising of one or the other harness. In this case every cord of the second harness must have two mails, one divided for the ground warp and the other with a single opening for the binding threads. If the number of threads in a warp section is not too large, the binding threads can be put with the ground warp through the compound mails, care being taken to restrict them to that front harness intended for the binding warp.

In drawing the paper pattern for such a fabric the ground to be formed by the atlas warp is marked white, and for every figure which has to show a different colour in the fabric a different colour must be used in the drawing as soon as the various threads do not appear as weft-changes of colour. The binding done by the second harness is also denoted by a special colour.

Those parts of the pattern woven gobelin fashion are not marked with binding points, as here all the threads of the second harness which enter into the figure are down. If figures made with the same weft show both gobelin and atlas weaving, both plans must be indicated on the paper by a special colour, as with the gobelin weaving all the threads of the second harness are down, but raised for atlas weaving.

By weft change colours we understand those which in the progress of the weaving supplement colours already present. In a three-coloured furniture damask, for example, say of blue, red and yellow, greater variety is attained if a light blue is taken instead of a dark blue weft, and a paler yellow and red instead of dark colours. Then, although the fabric will show six different shades, only three cards will be pierced for each weft line, as the original colour is only exchanged later for another, so as to shade off the pattern.

Arrangement of a Furniture Damask with many-threaded Lift.

This fabric must show unicoloured weft figures on a smooth atlas. The figures must be variously woven. The longer bare places must be shown by binding points, but they are unnecessary for shorter ones, which are left uncovered or open. The ground warp will be of chappe silk yarn, and the figure weft of the same, while for the binding warp and weft cotton yarn is used. The closeness is 219 ground warp threads to the cm., and 165 figure wefts to 5 cm. The ground warp is woven eight-leaved, the figure weft five-leaved. Hence the binding warp must be through lifters instead of shafts and the loom must have a double harness. A binding thread follows each three-thread warp section.

Process: Stuff-width, 120 cm. Width of reed, 125 cm. Material, chappe silk No. 140/2 for the ground warp. English cotton yarn No. 100/2 for the binding warp.

Figure weft: Chappe silk No. 140/2. Binding weft: English cotton yarn No. 100/2. 219 ground threads to 5 cm. and therefore 5016 altogether, and 5016/3 = 1672 warp sections. The width of the sketch for the fabric is 30 cm., so that in the width there

are four repetitions of the pattern in the ground warp of the first harness, each with 418 warp sections.

As the binding warp stands in the same relation as the ground warp there must be the same repetition of 418 lifters for the second harness. Thus there are 836 lifters altogether, *i.e.*, an 800 machine of fine spacing.

The binding of the ground warp with the binding weft is eight-leaved warp atlas, so that eight front harnesses with cord eyes six to seven cm. long are required, and can be worked direct on the Jacquard.

If we add to the 836 lifters four others for end selvedges, forty are left for moving the harness. With four lifters to each harness, we have thirty-two in two cross rows. The first harness takes Nos. 1-418; the second, Nos. 419-836. If the 418 are divided into cross rows of sixteen, we get twenty-six rows and two over. Hence the second harness begins with No. 3 of the twenty-seventh row. Hence to bring the cross rows into correspondence with the rows of holes in the comber board, it is better to omit the two lifters over, and only to use 416, *i.e.*, twenty-six rows exactly. Although this dispenses with six ground warp threads in each repetition, *i.e.*, twenty-four altogether, the close spacing makes such a small number of no importance.

The proper arrangement of the Jacquard then is first harness, lifters 1-416. Each lifter has four cords, each with a threefold metal eye. Lifters 417-832 form the second harness. Each of these has four cords, each with a single eye.

The following two rows of lifters are for the front harnesses, four to a harness:—

Number	1	harness,	lifters	833, 834,	left;	847, 848,	right.
,,	2	,,	,,	835, 836,	,,	845, 846,	,,
,,	3	,,	,,	837, 838,	,,	843, 844,	,,
,,	4	,,	,,	839, 840,	,,	841, 842,	,,
,,	5	,,	,,	849, 850,	,,	863, 864,	,,
,,	6	,,	,,	851, 852,	,,	861, 862,	,,
,,	7	,,	,,	853, 854,	,,	859, 860,	,,
,,	8	,,	,,	855, 856,	,,	857, 858,	,,

Lifters 865-866 and for the end selvedges, each with eight cords to a mail with a double ground thread; Nos. 867-880 remain empty.

The comber board receives 832 + 4 = 3328 holes in two sets of 1664 each, and for the end selvedges eight holes more are made right and left, and the order of the cords is uniformly divided for the four repetitions. The front eight harnesses have 624 cord eyes six to seven cm. long. 5016 threads are not warped for the ground warp, as given above, but according to the number of lifters, 4992 threads. To these are added eight double threads at beginning and end of the fabric for selvedges. For the binding warp, $1664 = \frac{4992}{3}$ threads are warped.

The paper pattern will show seventy-three warp sections and 165 figure wefts to 5 cm. = 8:18 (*i.e.*, eight lines for warp and eighteen for weft). It is executed as shown in Fig. 55. The atlas of the binding warp is drawn with binding and figure wefts on the white ground, with yellow, ⊡, and on the red parts of the pattern, where the weft is bound, with carmine, ⊠, and where the weft is not bound with black, ■. The reading for the right side of the fabric is as follows. Each weft line gets two cards. For the first card (figure weft) in the first harness, red, black and carmine; and in the second harness, white, □, yellow, red and black; for the second card (binding weft), blank for the first harness, and white and red in the second. For the first card there is no heald lifting, for the second the lift is denoted by red. For the end selvedges white is used for both cards.

The ground threads pass first through the Jacquard mails and then through those of the harnesses. After every three threads of the first harness comes a binding thread which passes through a Jacquard mail of the second harness and free through the front healds. In the reed each warp section of thread occupies one dent, and the corresponding binding thread is in the same dent.

CHAPTER IV.

DAMASKS WITH GROUND AND BINDING WARP THREADS— (*Continued*).

6. Lampas.

These are damasks for hangings, and show raised figures in warp atlas, formed by weft usually on a twill ground. With these simple goods there is only one warp, of which the threads are lifted singly, and not in sections, so that the fabric is an ordinary Jacquard one. Nevertheless, two wefts are required of which one, of rather stronger material, has to be regarded as a ground weft in so far as it gives binding to the fabric, and is not visible on the right side. The second weft serves to outline the figure, and on the right side only occurs at places which are to appear as ground. If in such a fabric the right side is put upwards, and the figure weft is carefully removed with a needle, a smooth atlas is left.

If the figure weft is on atlas, the weave is so managed that the wefts lying bare over seven warps completely cover the binding places of the ground weft.

In Fig. 55 (Plate VII.) the sign [|] means the yellow figure weft where it is visible on the right side. [\] (red) shows the binding place of the ground weft, covered entirely by the bare parts of the figure weft. White, □, means warp. The figure weft occurring on parts of the wrong side is sixteen-leaved. These binding places must be put so as to be invisible on the right side. This can only be done by their falling on the same threads with the binding places of the ground weft. In drawing the paper pattern all those conditions must be borne in mind if both wefts are to weave correctly. Fig. 56 (Plate VIII.) shows a part of such a paper with binding points, as required by the arrangement

of Fig. 57 (Plate VIII.). The figure is marked with any colour, say yellow, and the ground is left blank. As the ground weft weaves in atlas over the whole width of the fabric, this weave must be denoted throughout by another colour, say red. On the right side, to get eight-leaved warp atlas, this weft must be white and yellow where in the lower shed, and red for the upper shed.

The second weft must be woven in the pattern on the wrong side in sixteen-leaved atlas, and the binding places must coincide singly with those of the eight-leaved weft atlas. The places for both wefts are marked on the paper with carmine.

At the ground places this figure weft must be on the right side and be woven eight-leaved, and the binding places must be marked on the paper for the proper warp with a different colour.

The first figure weft binds here with the third warp thread, so that this point must be brought on the paper on to the third warp and first weft, because every weft line corresponds to both wefts. Green, ⊡, should be the colour used. Thus the reading is as follows:—

Each weft line has two cards: for the first card, red and carmine; for the second, white and red. Hence for the first (ground) weft eight-leaved atlas must remain down, so we have red and carmine; for the second (figure) weft, the eight-leaved warp atlas must be lifted in the ground, to make this weft visible on the right side. Hence we have white and red. As, now, red proceeds in sixteen-leaved atlas, this will secure the proper weave on the wrong side.

Because the ground weft is woven in over the whole width of the fabric, there is a possibility of making the shed for this weft with tringles under the comber board, and so saving a Jacquard card on each weft line.

Other sorts of lampas have a much closer warp, and are made with the warp in sections. The figuring is, however, the same as before, *i.e.*, a raised warp atlas pattern on a weft ground bound at intervals. There are again two wefts, a ground weft and a figure weft. But the latter is not bound by the atlas warp but by a binding warp.

Fig. 56.
Pattern

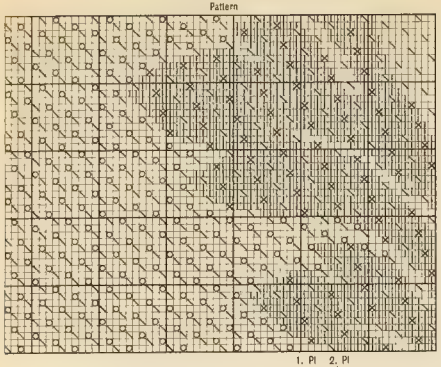
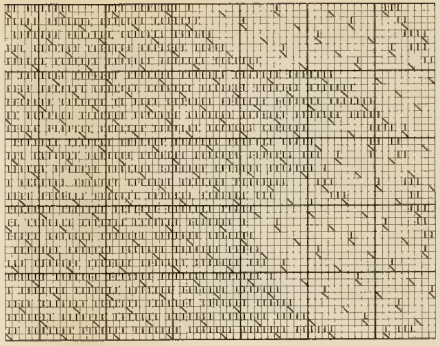


Fig. 57.
View of crossweaving



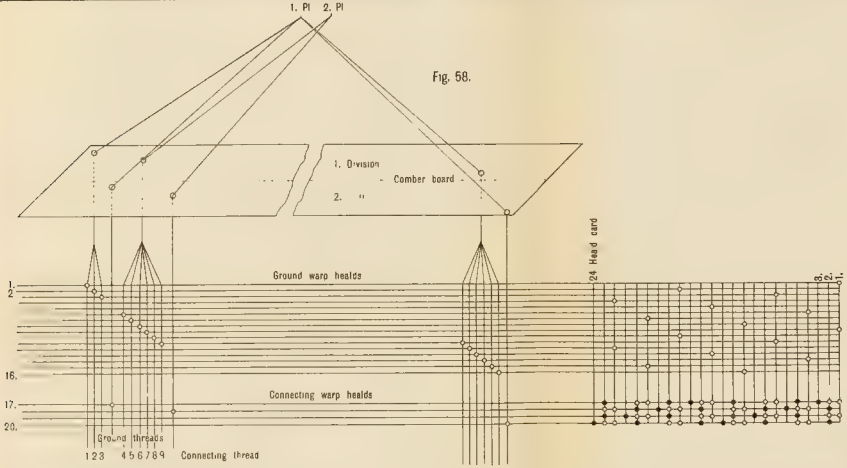


Fig. 58.

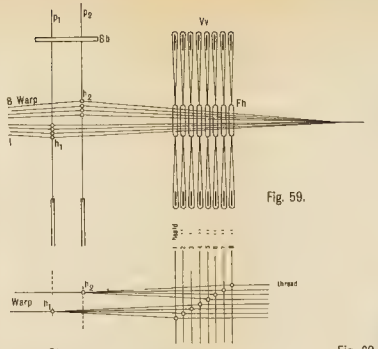


Fig. 59.

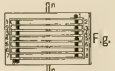


Fig. 65.

Fig. 69.

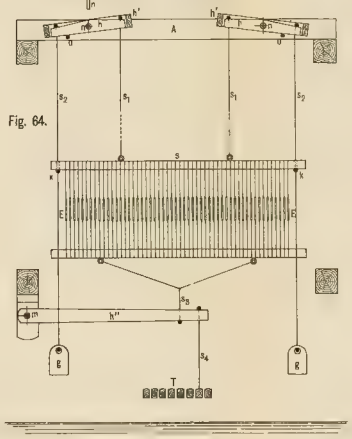


Fig. 64.

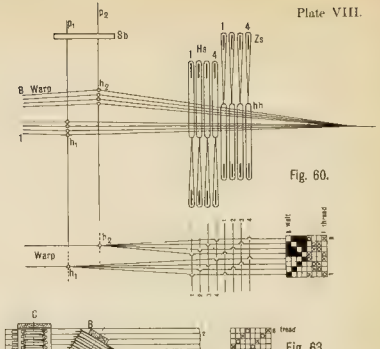


Fig. 60.

Fig. 62.

Fig. 63.

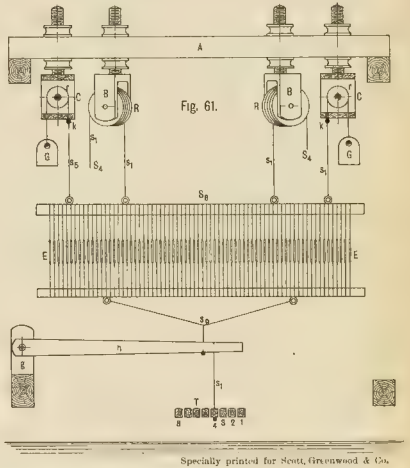


Fig. 61.

Kinzer and Walter, Damask weaving

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The loom arrangement is like that shown in Fig. 42 (Plate V.). Several atlas warps go through each Jacquard mail, but they pass singly through those of the front harness, there being another front harness as well as the Jacquard for the binding warp. Both front harnesses can be lifted for a high shed, and as ground wefts are picked the atlas warp rises for eight-leaved atlas, the binding warp for four-leaved twill. This shed is worked by the shaft machine only. The second weft, of silk, weaves at intervals in the ground. At these places, therefore, the atlas warp and the binding warp must be again lifted in four-leaved warp twill, to get the weft twill on the right side of the fabric. This is the only weft that needs a card, and is shown by white on the paper if the figure is shown by colours.

Another variation is got by making the binding warp show the weft on both sides, *e.g.*, ground warp in eight-leaved atlas and binding warp in three-leaved weft twill. Here, too, the binding warp is lifted by the lifters and the ground warp with it, and then worked by a front harness. The shed for the ground (binding) weft is worked by the shaft machine lifting of atlas and binding warp together, one shaft at a time. For the upper (figure) weft the atlas warp rises altogether, and the binding warp is lifted, so far as the same shaft as for the previous binding weft is concerned, the third shaft remaining down.

Church Damasks.

Damasks are largely used for Church fabrics. They are very commonly made of silk, into which gold and silver threads are often woven. They are always set high in the warp, so that the warp cannot be in sections, and the rather that the patterns are almost always much larger than in lay damasks. Simple Church fabrics are made of half damask with one warp and at most two wefts. The figures are then usually formed by the weft, either uniformly woven in smooth atlas, or with different weaves to get differences of effect.

There may, too, be two warps, one forming an atlas ground, the other, of a different colour, forming the figure with the weft.

Under the ground weave the second warp lies in pattern on the wrong side without binding. This technique is to be considered as a special use of warp.

Among more complicated Church fabrics are those with both a ground and a binding warp, the former being raised in sections. There is, however, only one weft which can be woven with the binding warp in various ways for the pattern. The arrangement is like that shown in Fig. 46 (Plate VII.), except that the shaft card must be altered as there is no binding weft.

Another sort of this fabric is made with a silk warp and two differently coloured wefts. The ground is formed by close weaving the warp with the weft nearest to it in colour. The other weft is loosely woven on the wrong side so as to cover the binding places, and so as to be invisible on the right side.

Both wefts can be used for the figure and woven closer or wider as required. Other Church goods are made with a simple damask raised in sections. There is only one kind of warp and weft, and the figures show in bright shades on a dull ground, with warp and weft atlas. It is not always necessary that the steps in the pattern outline in the weft direction should be in warp sections. A fine warp of organsine silk and a rather strong trame weft are often used. In this case the steps may consist of just one weft thread, and the paper pattern has to be made accordingly. By using a trame weft with several shuttles, the weft figures acquire a ribbed appearance, and show off the smooth shining atlas surface better.

Another variation consists of goods in which the warp forms the atlas ground, while the weft is woven for the figure not by a ground warp lifted in sections but by a binding warp. For the ground atlas special binding wefts are used, which are invisible on the right side, and can therefore be made of inferior material. In spite of there being two warps a second harness is not wanted, as the atlas warp is put several threads together through the Jacquard mails, and in single threads through those of a front harness, while the binding warp is worked by another front harness only. The right side is put underneath in the loom, and

when the figure weft is picked the ground warp rises as a whole, the binding warp in single threads afterwards (Fig. 42, Plate V.). When the binding weft is picked only one front harness is raised, the shed of the binding warp remaining as for the other weft. Both front harnesses have a rising gear only, and when the binding weft is picked there is a half cross shed of the ground warp.

A good loom arrangement for these fabrics is one in which the binding warp is moved by the same lifter with the ground warp section, the front harness of the ground warp by lifting gear only, and that of the binding weft by both lifting and sinking gear. The following will explain this more fully.

The fabric must have a red ground warp woven atlas. This ground contains weft figures, shaded by alternating light and dark yellow silk wefts. Both wefts go over the whole width of the fabric. The light and dark yellow figures contain broché weft places. As these figures are distributed irregularly, the broché wefts must be inserted with embroidery shuttles, the pirns in which again wind up automatically any excess or thread that has left them. The broché wefts are of gold or silver lace.

The ground and binding warps are of red organsine silk, the yellow wefts of trame, and chappe silk on three pirns is used for ground or binding weft.

To get a fine lustrous ground, the warp is made of twenty-two sections of six threads each to the centimetre, a binding thread after each warp section. The width of the fabric is 54 cm. without end selvedges, so that there are 1188 warp sections. The design must show a symmetrical pattern, *i.e.*, the whole width without repetition. Hence $1188/2 = 599$ lifters are wanted, and thus a 600 machine.

The arrangement is best as shown in Fig. 58 (Plate VIII.). The lifters raise the eyes with the ground warp and the binding warp, but a double harness would be better. Each lifter has four cords, two for the ground warp, in the first and last hole of the hinder division of the comber board. The two other cords are in the front division, but also in the first and last hole. The comber

board must therefore be in two divisions, be 58 cm. wide, and have 1200 holes.

Each cord of the hinder division has a glass mail in six sections, and each of the front division a simple mail. In putting the warp through, we begin on the left with a mail of the hinder division, giving each compound mail a half warp section of three threads. Then comes a binding thread through a mail of the other division of the board. In each of the other mails of the hinder division we put a whole warp section, and after each one a single binding thread in a mail of the front division. In the diagram, Fig. 58, we see that the first lifter on the left-hand side has three threads, and the second has six. When we have finished warping the Jacquard, we put on sixteen front harnesses for the ground warp, and four for the binding warp. The ground warp from the hinder division of the board passes thread by thread through long eyes in harnesses Nos. 1-16, and the binding threads from the front division through long eyes in Nos. 17-20. The reed takes six ground threads and one binding thread to the dent. As the first mail of the hinder division has only three threads, they, the first binding thread, and three threads of the second warp section, will all come in the first dent. Hence the binding thread is separated from the wires of the reed by ground threads, which helps very much to getting a good atlas, and that is the reason for the arrangement which has just been described. The shaft machine lowers, raises and pauses the front harnesses, but the sixteen for the ground weft are lifted only, the four for the binding weft being both raised and lowered.

The ground warp makes eight-leaved weft atlas with the binding weft, as the fabric is right side downwards in the loom. The binding warp at the same time weaves in taffeta with the same weft.

When the yellow wefts are picked the ground warp is lifted all together, and the weave is produced taffeta by the binding warp. The broché wefts too weave with the binding warp only, and in four-leaved twill.

The picking of the binding weft requires shedding by the shaft

machine. Two of the ground front harnesses rise correspondingly to the eight-leaved atlas, and two of the front harnesses for the binding warp rise correspondingly to taffeta, the Jacquard remaining at rest. After the binding weft comes a figure weft, for which the Jacquard lifts the whole of the ground warp, and at the same time its binding threads go into the upper shed, but part of them must be returned to the lower shed for the taffeta weaving.

Where no ground warp is raised there are no binding threads in the upper shed, so that two of the front harnesses, Nos. 17-20, must rise, and two fall, forming a cross shed. For each different broché weft a shed must be formed, one for a gold, another for a silver thread. The Jacquard lifts the ground warp with its binding threads and of them a part is again lowered for four-leaved weft twill, to bind the broché threads on the right side of the fabric.

For the second broché weft the shed of the shaft machine remains open, and the Jacquard has to form a new shed.

The paper pattern for this fabric is drawn 8 : 8, as to a warp spacing of twenty-two sections corresponds a weft spacing of twenty-one figure threads, and three colours are used on the paper without reference to any weaving. The atlas ground remains vacant, the parts denoting figure wefts are marked red, those denoting silver broché threads blue, and those denoting gold broché threads green.

Each weft line has three cards :—

For the first card (figure weft) read red.
,, ,, second ,, (gold broché) ,, green.
,, ,, third ,, (silver broché) ,, blue.

The weft order is therefore: a ground or atlas weft, a figure weft alternately light and dark yellow, a gold and a silver broché weft.

PART II.

THE METHODS OF MANUFACTURE OF WHOLE DAMASK.

INTRODUCTION.

BEFORE we can discuss the special arrangements and methods of working for damasks, it will be of interest to say something of the history of the manufacture, which reached a high stage of development with the invention of the Jacquard, which simplifies the process, and opens new fields for it.

Till 1604 the Eastern hand loom was used in Europe. It contained a number of ground shafts and the front harnesses still largely used. In 1604, Simblot, a Frenchman, instituted a better harness motion, which somewhat facilitated the working of the treads by a second workman. In 1687 Joseph Mason succeeded in bringing all the motions under the control of one man. In 1779, William Cheape introduced an overhead harness pulled down by hand. All these primitive contrivances naturally greatly limited the variety of pattern. By damask we usually mean the finest productions of the linen loom, and the patterns have greatly developed. To-day we make with fairly simple apparatus fabrics which formerly offered great difficulties, and use of front harnesses with the Jacquard was a very important piece of progress. Without them the weaving of large patterns is hard, because they would else require very wide Jacquards with an immense number of hooks. There are fabrics in which there are over 6000 threads in the reed. In practice the difficulty is overcome by using three, and sometimes four, 500 or 600 machines, putting more threads to a mail, and using front harnesses.

The closely spaced Jacquards introduced of late by Wiener,

Lacasse and Verdol, have formed a rival of the usual arrangement which cannot be undervalued, for Jacquards are now built with as many as 3960 hooks, and up to a certain point can displace the ordinary damask loom. Jacquard fabrics in which the outline of the pattern alters by only one thread at a time can be made by them strictly to design, but it does not pay to have such machines for cheap goods. One drawback of these machines is the enormous number of cards wanted, and with very close and wide fabrics they will not make a large enough pattern, which can only be got by raising several threads at once. Why should not the very close brocades woven in silk have not still larger patterns, to show off the material better? We can say then that the large Jacquards extend damask weaving and enable a less limited size of pattern to be produced.

A very important matter is the application of the power loom to damask weaving. The power loom was invented in 1787, and brought about a revolution in weaving. It enables the most difficult fabrics to be executed, and is therefore supplanting hand weaving. One result of the invention is the long-sought-for suppression of the cross shed and of the front harness, and there is great hope now that it may be applied to damask weaving. A few difficulties still remain, but will doubtless soon disappear. Damask weaving will then stand side by side with Jacquard weaving, for the latter serves the former, and the former perfects the latter. Hermann Wilkie showed a new way with his damask Jacquard, as did Hermann Gunther in 1882. Other machines have brought the solution of the problem still nearer.

The simple arrangement of treads or shaft machine, worked by the feet, only allows a limited variety of patterns, especially with angular outlines, which always have a more or less square appearance. As things are now, however, the possibilities of patterns are increased, and the outlines need not change step fashion. The outline produced by the warp rising in sections with the Jacquard gives the characteristic appearance of damask.

It must be remembered that the Jacquard serves only for pattern making and not for binding. Hence the single thread

insertion into the front harnesses to supply the deficiency. This works, for example, that one harness rises, and another falls, while the rest remain stationary. The first raises the warp into the upper shed to bind the ground and the second brings into the lower shed those warp threads which bind the pattern. The weft points in the figure and the warp points in the ground always belong to different harnesses, but the binding points of weft and warp effects must never hide one another (see Figs. 19-21, and 23-25, Plate III.). Hence a rising front harness only lifts threads from the lower shed, and a falling one only brings down threads from a pattern in the upper shed. This produces the cross shedding between the Jacquard and the front healds. But if the mails of the Jacquard simply form an ordinary shed, a limit is put to the weaving.

We distinguish two methods of manufacture, one with front harnesses and a cross shed, and one without.

CHAPTER V.

DAMASK ARRANGEMENTS WITH CROSS SHEDDING.

THE front harness is moved independently, and may be single or double.

The single harness (Fig. 59, Plate VIII.) has special healds with eyes, F*h*, six to ten cm. high, so as to give the warp threads sufficient play when the figure healds, *h*, are lifted, and also to make a wide enough shade for the shuttle, although that is made as thin as possible. The repeat of the binding is equal to the number of harnesses.

The double harness (Fig. 60, Plate VIII.) has half eyes, which in one to four, H*s*, only lift warp threads, and such as in healds one to four, Z*s*, can only go down. One half of the harness forms the lifting, the other half the falling mechanism. The repeat of the binding is equal to the number of healds in a half. Each thread is put through a rising and a sinking heald.

The position of the front harness is so arranged that the warp threads lie light in the lower eyes, and the sinking part, Z*s*, must hang high enough for the warp threads to form a shed. The front harness is worked by treads, the number of which depends upon the number of repeats in the binding, and also on the lowering mechanism. The weaver works the Jacquard treads with his right foot, and those of the front harnesses with his left, or *vice versâ*. If a shaft machine (witch loom) is used instead of treads, one foot moves the Jacquard, the other the shaft machine.

In most cases the figure tread is kept in action until the working of the ground treads has put in enough weft threads to form the pattern through the whole length of the fabric. Sometimes, however, there is a tread which moves both Jacquard and

shaft machine. The first remains up, and the latter works steadily according to the grading of the outline, till a reserve hook brings down the griffe.

1. Roller Mechanism for Working the Harness.

This simple arrangement is largely used in spite of its defects. Over the loom at A (Fig. 91, Plate VIII.) roller cases, C and B, are fixed symmetrically by screws. The case, C, contains eight rollers, *r*, cords over which are fastened at one end to the harnesses, E, at the other to weights, G. The two weights for each harness are together somewhat greater than those of harness lever, *h*, and tread, T, together. They would, therefore, raise the harness above its normal position. The cords, *s*, *s*, run through the floor of the roller case and at K have a knot, which when brought against the hole in the floor stops the harness at its normal place. Fig. 62 (Plate VIII.) shows the relative positions of rollers parallel to the harnesses. The second case contains only four rollers, R, which are placed obliquely to the harness.

From the binding shown in Fig. 63 (Plate VIII.),

Harness 1 falls and 5 rises
,, 2 rises ,, 6 falls
,, 3 falls ,, 7 rises
,, 4 rises ,, 8 falls

so that Nos. 1 and 5, 2 and 6, 3 and 7, and 4 and 8 must be corded together by the cords, s_1. Each harness is guided by a lever, *h*, which, corresponding to the eight-leaved atlas, is corded to each tread. Hence the depressed tread lowers one of the two connected harnesses and raises the other, the rest remaining at rest. The disadvantage of this is improper combination of warp and weft binding, as the sharp boundary of the weft in the warp effect is wanting. This makes itself evident especially with line outlines, as one thread rides over another in the outline, so that the pattern effects show greater and smaller breadth, and *vice versâ* on the wrong side.

Almost as simple as advantageous is the lever-depressing mechanism shown in Figs. 64-66 (Plate VIII.). Here over the

loom at A are cases, h_1, left and right, which replace the roller mechanism entirely. This lever arrangement consists of seven levers, and the frame-shaped lever, h_1, which encloses them. All the levers are equal-armed with a fulcrum at the bolt, n, and with the normal position of the harness are supported by the bar, o.

According to the weave shown in Fig. 66 (Plate VIII.),

Harness 3 rises, harness 1 falls.
,, 5 ,, ,, 6 ,,
,, 2 ,, ,, 3 ,,
,, 7 ,, ,, 8 ,,
,, 4 ,, ,, 5 ,,
,, 1 ,, ,, 2 ,,
,, 6 ,, ,, 7 ,,
,, 3 ,, ,, 4 ,,

Hence harnesses 1 and 2, 2 and 3, 3 and 4, 4 and 5, 5 and 6, 6 and 7, 7 and 8, and 8 and 1 have to be indirectly connected by cords, S_1, S_2, and the lever, h. Hence the first harness hangs at the inner end of the frame, and the eighth at the outer end, so that the cord on which the counterpoise hangs goes through the upper batten, and is knotted at K just below it, so that as the first harness is lowered the eighth is raised. In like manner by means of the lever and the knot, the second harness lifts the first as it falls. The outer ends of the levers therefore carry the knotted cords in the order shown in Fig. 65 (Plate VIII.). Here, too, the treads are connected with the harnesses in eight-leaved atlas. The disadvantage shown in Fig. 61 (Plate VIII.) is here lessened, because the outline is bound in the direction of the weft, as soon as the section lifting corresponds with the binding. This lever arrangement is a good deal used.

2. Counterpoise Working of the Harness.

Both the already described lever arrangements allow the eight-leaved atlas only in the forms shown in Figs. 63 and 66 (Plate VIII.). If this is to be avoided counterpoises must be used and also disconnecting arrangements for the motionless harnesses (Fig. 67, Plate IX.).

Each harness has the cording, s, s_1, s_3 and s_2, with the upper lever, Ph, and the lower short lever, Kh, and the long one, Lh. These levers have their fulcra at 1, 2, 3, respectively. The end of Lh also receives the cord, s_4, with the knot, K, and weight, G, in the case, B. The weight brings back the harness to its normal position. The connection with the treads is shown in Fig. 68 (Plate IX.), where × shows the place where a tread is tied to the long lever, and ○ where it is tied to the short one. Each tread is thus connected with a long and with a short lever, while the other points are uncorded and their harnesses remain at rest. Through the independence of the cording the rising and falling points may be variously arranged. This counterpoising, shown in Fig. 67 (Plate IX.), is for narrow damasks. For wide looms a similar arrangement shown in Fig. 69 (Plate IX.) is used, where for restoring the harnesses to the normal position we have the weights right and left over the loom, with the knotted cords, s_8, s_9, the knots, K, and the perforated board, B, while s_7 is fastened to the upper batten of the harness. The weight levers, Oh, turn in the bolt four and over the loom. The remaining harness connection is easily seen. To work the double harness, the lifting arrangement makes the upper shed and the lowering mechanism the lower shed. Those shafts only are corded together which are moved by the same tread.

In this tread arrangement the work is rather difficult and requires experienced workmen, men who are sought after and prized, but are unhappily rare.

The movement of the treads to form the sheds by means of the front harnesses requires a gentle pressure, or else the threads will be under unequal tension and they will be constantly breaking. The number of treads, too, which may amount to twelve, is a hindrance to the weaving. In ordinary damask work they are moved to the weaver, and he has to manage eight besides those which make the pattern shed of the Jacquard. Hence he has to be seated, a posture in which the working of the Jacquard is very fatiguing.

Damasks got with the use of treads have a pleasant appearance,

depending on a special even tension in the threads. The fabric is closed and flat. The modern generation of weavers much prefers a shaft machine to treads.

3. The Shaft Machine (Witch Loom).

The oldest of these machines is a combination of an ordinary lifting machine with a roller arrangement for sinking. It is shown in Fig. 70 (Plate IX.). Each harness hangs on a roller, *r*, over which runs a hook cord each of whose ends is fixed to a hook, P. The arrangement of these hooks regulates that of harness, and there are three arrangements. If, say, hooks Nos. 1 and 2 are taken, the harness, S_1, is lifted, but if Nos. 3 and 4, the harness, S_2, remains down, but if, say, No. 5 is taken, the harness, S_3, remains in a passive intermediate position. This is necessary, to make room for the figure shed. A direct lowering by a simple high warp shaft machine is impossible.

With this mechanism, which allows various weaves, a continuous motion of all the harness is required, which is not advantageous, as it entails much rubbing of the warp. Hence shaft machines have been constructed which only move the harnesses corresponding to the binding, the others remaining unmoved. Fig. 71 (Plate IX.) shows such a machine, placed by the side of the loom on the upper side bar, R. It has a fixed floor, P*b*, through which the hooks go. When at rest the harness exerts no pull on the hooks, which are kept by the spiral springs, F_1 and F_2, high over the knives of the griffe. Each harness is worked by two hooks, *pt* and *ph*, the former lowering, the latter raising it.

The rows of needles, n_1 and n_2, direct the hooks, which are also in two rows, separately and are raised by the griffe and the usual lever arrangement. The prism, P*r*, has two rows of holes, the first for the needles for lowering, the second for the needles for raising the harness. If, for example, the weave has to be according to Fig. 72 (Plate IX.), the cards have to be pierced as in Fig. 73 (Plate IX.). A hole in the first row of the card causes lowering, a hole in the second row lifting, and the unperforated places in both rows cause the hooks to be pressed down below the

knives, so that the harnesses concerned stand still. With the weave in Fig. 72 (Plate IX.) only one hole must be pierced in each row.

The process is as follows. A card on the cylinder pushes seven hooks away from the knife through the unperforated places in each row of needles, while a lifting hook of the necessary harness and a sinker of another harness hang on the knife and so rise with the griffe. The correspondingly depressed hooks of both harnesses moved are pulled down as they are led into the floor, P*b*. This is made possible by the springs, F. In another construction the spiral springs are pushed against the hooks (Fig. 74, Plate IX.), and are supported at one end by P*b*, and at the other by a thickened part of the hook at *o*. If *ph* is lifted, the spring concerned comes out of action, while that of *pt* is compressed, and at the falling of the griffe brings the hooks to their normal positions. In Fig. 75 (Plate IX.) a single flat spiral spring, F, works two opposite hooks. They sit by means of projections, O and F, and the striker, *m*, limits the stroke of the springs. If *pt* rises, *ph* falls and presses the spring down. These machines may be on the right or left, or in the middle of the loom. They have the corresponding lever arrangements, one usual in German damask looms being shown in Fig. 76 (Plate IX.). Each harness hangs on cords, s_1, to the two-armed levers, h_1, which work in bearings on the bolt 1 of the upper part, A, of the loom. The inner ends are connected by cords, s_2, with the lever, h_3, at the bolt 2. The outer end of h_3 is pulled with h_8 by the rising hook. The lower harness bar hangs by the cord, s_3, on the equal-armed lever, h_4, connected by *st* with the falling hook.

To keep the harness in the normal standing position a spring case, G, is put above the loom, and each of the levers, h_3, is connected by a cord, s_4, with a rod, B, which is in the case, and there bears upon a spring, and regulates the stroke of the spring, according to the position of the harness. With this arrangement no weights are used. Fig. 77 (Plate IX.) shows such another arrangement at the side of the loom. It is distinguished from the previous one by the replacement of the spring case by weights

attached to levers, h_2. The hook, *ph*, with the levers, h_2 and h_1, raises the harness, and *pt* with h_3 and h_4 lowers it. The thickened lever ends, *m*, rest on the support, *n*, and by their weight bring the harness from the lower position to the intermediate one.

Fig. 78 (Plate X.) shows the shaft machine in the middle, for wide looms. The counter pull is obtained by a lower top frame, B, with levers, h_1, and a cord, s_2, passing through the warp. The weighted lever, h_2, with thickened end, *m*, restores the middle position. The cord, s_2, is bad for fine fabrics, as it rubs against the warp and damages it.

To prevent this we have the arrangement shown in Fig. 79 (Plate X.), in which the pulling cord, s_3, of the lowering hook, P*t*, is led over the roller, *r*, and connects the harness below the counter levers, h_3. The shaft machine, SM, has no springs, as P*t* and P*h* rest on a lever, h_1, which replaces the floor, P*b*. The lever, h_1, has its fulcrum at 1, and at its outer end is connected by the cords, s_4 and s_5, with the compensating weight, G, so that the free movement of the two hooks is not impeded. It is obvious that as many loaded levers are required as there are harnesses. The weighted levers, h_4, restore the harnesses to the normal position.

Although the work is sensibly easier and simpler with a shaft machine and one tread than with ordinary weaving with many treads, there are still two for the weaver to manage, the Jacquard tread and the shaft machine tread. The weaver works standing, and yet the working of the Jacquard tread, which cannot influence any weft, is waste of time, as it usually occurs after every two or three picks.

To get rid of this inconvenience Gustav Schwarz, of Kornthal, Wurtemberg, took out a patent in 1883, for moving both Jacquard and shaft machine with a single tread, so that every time it is pressed down, a weft is picked, and the damask loom can be worked as fast as a plain Jacquard. His shaft machine is shown in Figs. 80-84 (Plate X.). Fig. 80 shows it in cross section when at rest. Figs. 81 and 82 are various checking arrangements applied to the Jacquard lever or roller. This stop is connected by a cord on the spring, f_1, with a reserve hook on the shaft machine. The front

harnesses, S_1 (Fig. 80), are corded with cord, s, led over the rollers, R. The hooks on the cords, s_1, carry on their heads the weights, G, to bring the harnesses back to the normal position. The arrangement constitutes an inverted shaft machine without a floor, and under the harnesses. The hooks, P, in the grid, r_1, lead straight through the rollers, r_3, the hook cards in the grid, r_2, through the rollers, r_4, can be pressed over the knife by cams or the cards, k, of a hexagonal prism. The griffe, t, with the spring knife, m, is lowered by the tread, T, and the drawbar, Z, in the slit, f, of the framing. Counter weights or strong springs bring the grille up again to the top position shown. If the weaver depresses T, the Jacquard is raised as usual by the cord, l, on the machine lever, H (Fig. 81), or by the cord, a, on the machine roller (Fig. 82), while the stop, K, rests over the rod, m, and keeps up the figure shed. Points 2, 4 and 0 are fixed. Besides a hook, P (Fig. 80), lowers one harness and raises the one connected with it so as to allow a pick. At the same time the prism, C, is turned and another hook pressed forward. As the Jacquard is kept lifted by the stop, the shaft machine works with the front harnesses only until a rod connected with any desired card throws the stop out of gear at the point of highest rise by means of a releasing hook. The action of the stop is made certain by the spring, f_2, or weights, C, and its withdrawal by the initial tension of the springs, f, during the pull of the reserve hook. In Fig. 83 the machine is brought over the harnesses, where all hooks not to be lifted by the griffe are pushed back by projections on it. In Fig. 84 springs, F, are substituted for the weights. The advantage of such an arrangement lies in avoiding having to run the Jacquard empty, and thereby the incitement was given to weave damask on a power loom.

4. Damask on the Power Loom.

As early as 1877 an Englishman, William Nicholson Liddell, patented a power loom arrangement for damask, but with the use of the cross shed. This apparatus is shown in Fig. 85 (Plate X.). The connecting rod, Z, of the loom forms at the top of the Jacquard traverse, T, a slot in which is the projection, o, attached to C on

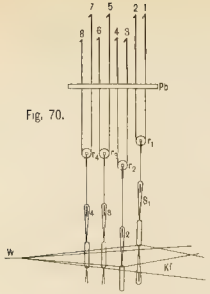

Fig. 70.

Fig. 68.

Fig. 72.

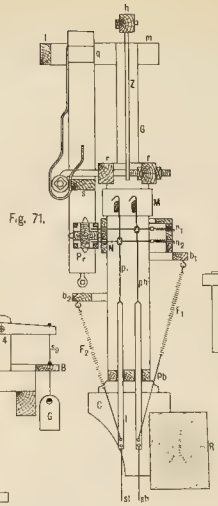

Fig. 71.

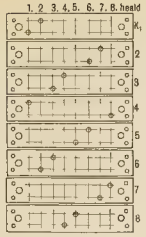

Fig. 73.

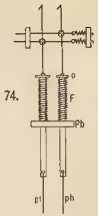

Fig. 74.

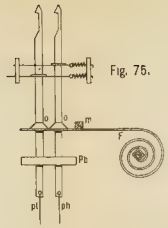

Fig. 75.

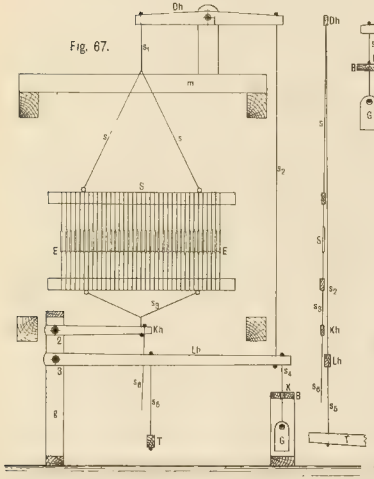

Fig. 67.

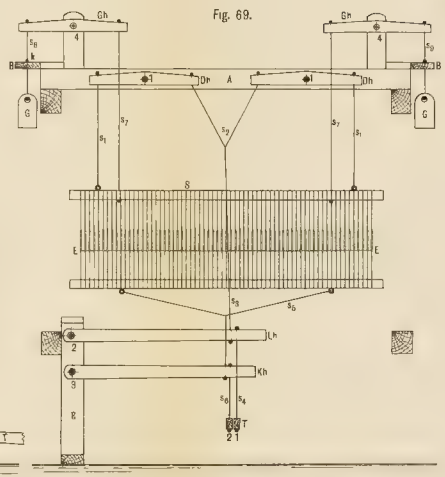

Fig. 69.

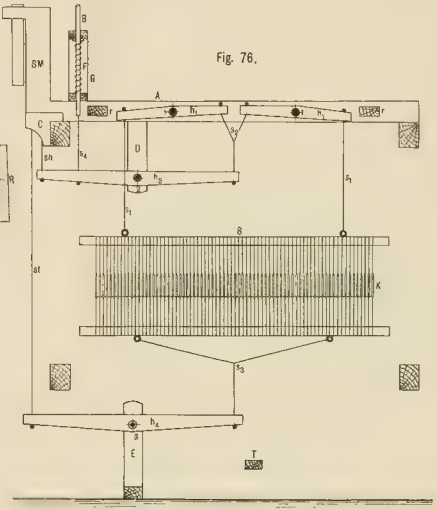

Fig. 76.

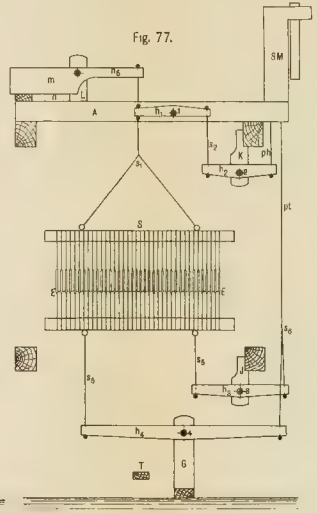

Fig. 77.

Back of
Foldout
Not Imaged

Fig. 74.

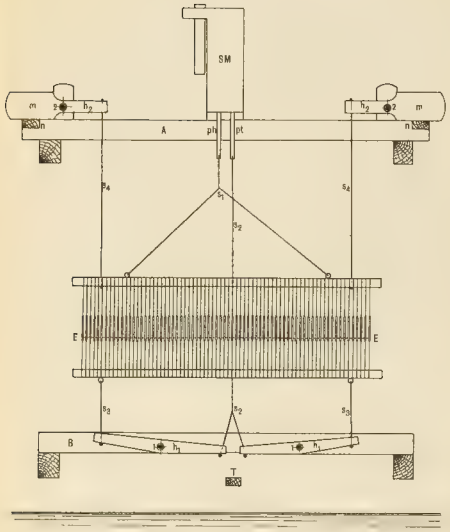

Fig. 79.

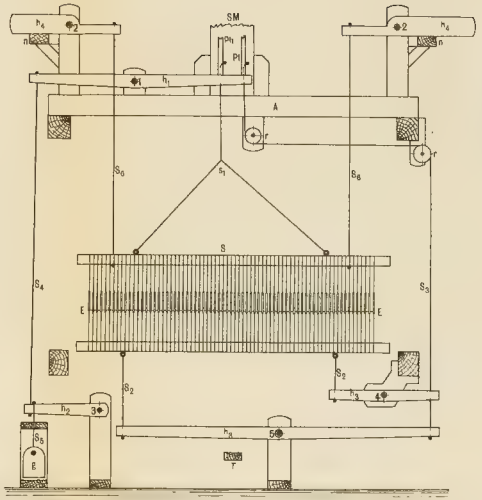

Fig. 80.

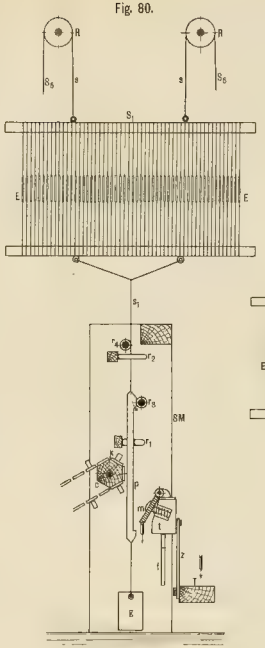

Fig. 83.

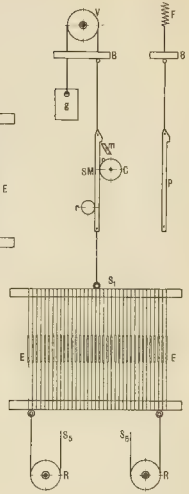

Fig. 84.

Fig. 85.

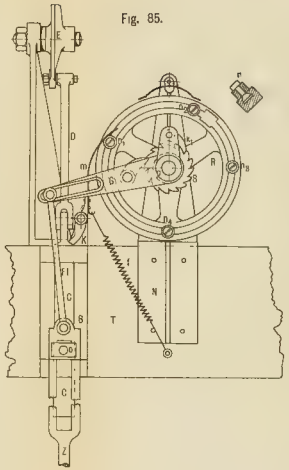

Fig. 81.

Fig. 82.

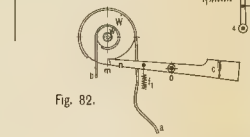

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Fig. 87.

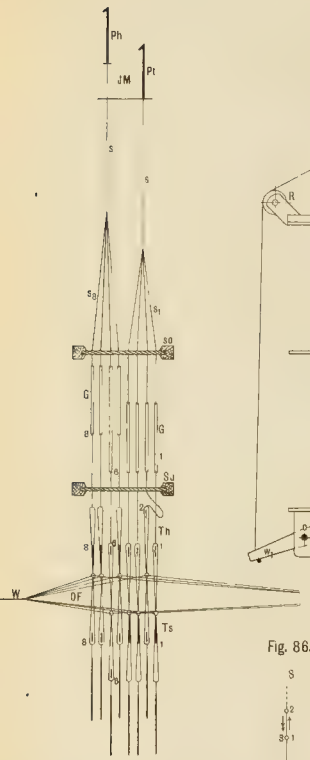

Fig. 89.

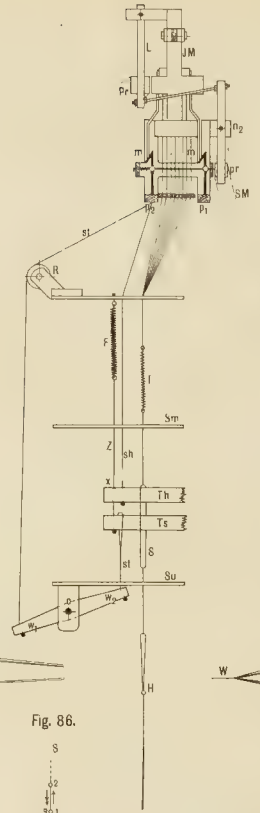

Fig. 88.

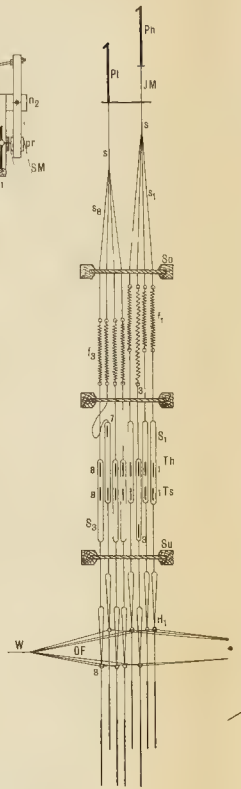

Fig. 86.

Fig. 91.

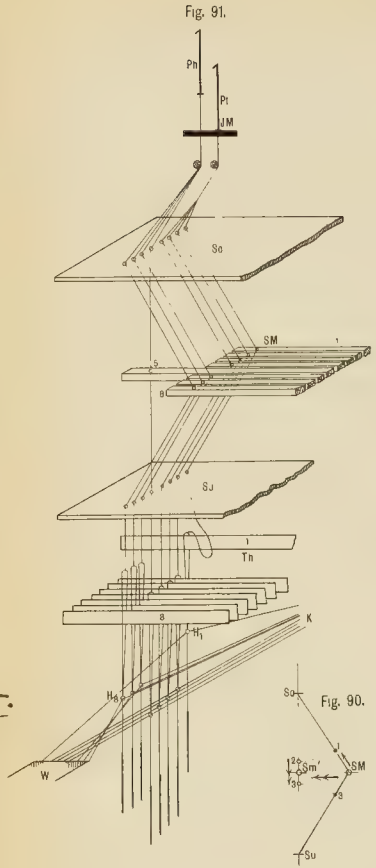

Fig. 90.

Fig. 93.

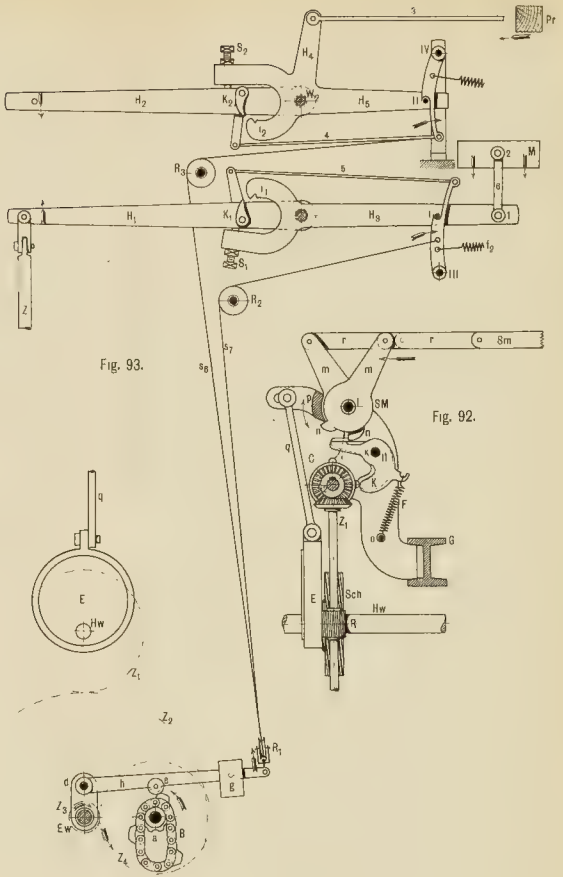

Fig. 92.

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the guide, B. C is connected with the short rod, D, and the Jacquard lever, E. In the drawing, C is in its lowest position, where the catch, K, holds it fast, so that the griffe remains up. The other end, *m*, of K is lengthened into a spring, which lies on the tappets, n_1 and n_2, which can be screwed into the wheel, R, where wanted. The wheel, R, and the ratchet wheel, G, which may have sixteen teeth, is prevented from turning back by the pawl, K_1, and by the regulating catch, K_2, on the lever, P, and the rod, F, is turned regularly tooth by tooth. As soon as the tappet, n_1, reaches *m*, *m* stretches and at the moment that the slot, Z, is at its lowest, with C somewhat lower, K is disengaged and the griffe falls and lifts a new figure shed, which remains open until the ratchet brings round the next tappet, when the performance is repeated over again. In this way four wefts can be picked in a figure shed, or four and three, or three and two, alternately. With this apparatus, which can be added to most Jacquard looms with very little difficulty, the griffe is allowed to fall freely at the speed of the rod, Z, and the number of revolutions is limited to 100, which is enough for most purposes. The front harnesses are worked by excentrics.

CHAPTER VI.

DAMASK ARRANGEMENTS WITHOUT CROSS SHEDDING.

In the arrangements hitherto described, in which there are front harness, the cross shedding is a drawback, the warp passing as it does through two sets of mails gets a double change of direction from the rising harness when it is down in the figure shed, and from the falling harness when it is up in the figure shed. This throws a great strain on the threads and may break them. One device for avoiding this is the half harness shown in Fig. 17 (Plate II.), which secures the yielding of the binding threads during the cross shedding. This plan complicates the warping, as each thread has to go through three eyes. A loom lengthened up to 2·5 m. is not always enough to lessen the tension of the threads. The object must be to get rid of the cross shed altogether. Hence the motion of the healds and the harness is so arranged that the warp threads only pass through one eye, so as to get an ordinary shed. The lifting of the warp is, as with half damask, not difficult, but the lowering of the warp raised by the Jacquard into the lower shed offers difficulties which have often been combated and with more or less success. The following is an account of some of the arrangements.

1. Altered Systems of Cording.

Fig. 86 (Plate XI.), where 1 shows the mail in the lower shed, 2 in the figure upper shed, and 3 in the binding lower shed, shows the object of the alteration. This consists in

(*a*) Using elastic cords of india-rubber. This was done by Schröder of Berlin as early as 1847, and he was awarded a prize for the idea. On the same principle is Eckhardt's arrangement

shown in Fig. 87 (Plate XI.). Eckhardt made at Chemnitz in 1860 a loom with tringles and no front harnesses, but tringles had been used as a substitute for healds before in Lyons, Vienna and Crefeld.

Eckhardt used sinking rods, T*s*, in the lower healds as well as raising rods, T*h*, in the neck cords. The latter are lifted according to the binding, the former lowered. This requires elastic cords of india-rubber. The figure hooks, P*h* and P*t*, are divided, according to the number of threads in a warp section, among single lifting cords, S_1, which pass separately into the comber board, S_0. Then the elastic cords, G, are united. Hook P*t* forms the lower shed, P*h* the upper. The rod, Th_2, is lifted and brings binding into the lower shed, whereby the cords above become loose. Ts_2 is lowered, stretches the india-rubber cords connected with it, and brings binding into the upper shed. The rods are moved by a shaft machine at the side of the loom. This arrangement excited some notice, but the india-rubber perishes in time, especially in dry heat, so that the idea had to be abandoned. The use of strong vulcanised india-rubber springs, or metallic spring of various forms lined or not with india-rubber, has answered better.

(*b*) *Bartel's Arrangement.*—J. Bartel, of Schönberg, following out Eckhardt's idea, improved it so far by using spiral springs of hard brass wire instead of lingoes, that not only hand looms but a power loom were worked with his contrivance, which is shown in Figs. 88 and 89 (Plate XI.). Instead of india-rubber cords, brass springs, f_1-f_8, twenty cm. long, are put between comber boards, S*o* and S*m*. The rods are removed and put in knots of the lifting cords between the comber boards, S*m* and S*u*, so that the rods, T*h* and T*s*, in the same knot raise or lower it, and so the mail itself, P*h*, is lifted, P*t* lowered, and the lingoes do not stretch the springs. The rod, Th_7, raises the knot and the mail, H_7; T_3 lowers the raised knot and mail, H_3.

The placing of the rods above a comber board is new and advantageous. They are moved by a shaft machine under the Jacquard, Fig. 89 (Plate XI.). Each needle of the shaft machine goes between the hook cords of the pattern machine and takes in

a hook (P_1, P_2) at each end, which are connected with the lowering rod by the cords, *st*, of the lever, W_1, OW_2. The hooks are arranged symmetrically left and right. The hook behind P_1 is connected directly with the lifting rod by the cord, *sh*. The rod, T*s*, is also kept up to the proper height by the spring, F. For leading the rod the cord, Z, of the lower rod goes through a hole, X, in the upper rod. The Jacquard arrangement under S*u*, and above and below the mails, is free and accessible to the weaver. The weaving is done with a fall of the griffe for each weft. The loom worked fairly satisfactorily at 100 revolutions with sixty wefts to the cm., making about ten serviettes a day. The disadvantages alleged are: difficulty in getting springs of exactly the right power, much time wanted for preliminary work, as well as greater space over the loom, and a shed too low for mechanically driven shuttles. The last is the result of the giving of the threads as they are lifted, as the tension of the warp has to be overcome. With wide looms a greater expenditure of force would be needed to pull down a rod.

We now come to the principal of the lifting cord standing at an angle. In 1844, Weigert, of Berlin, made a loom in which the cords were lengthened by the use of small comber boards that their mails remained in the lower shed during the stroke of the Jacquard. The loom has three comber boards, one above another. The uppermost and lowermost have eight rows of holes, and the usual tying. The middle one, however, is formed of eight single rods, carved out and supported in the middle. The comber boards carry the cords in the usual way, and are about twelve cm. apart. Each two opposite rods can be brought together or separated, in the first case by the cords, in the second by a special arrangement. The cords go from the uppermost board to the rods at an angle of 45°, and from there at the same angle to the lowermost board. If the lifting cords are pulled by the machine, they do not lift the mails attached to them, but only pull the rods together and leave the warp down. It is only when the rods are pulled that the harness cords lift the mails. As in the present case the loom is intended for making a double fabric, four cards are attached to each hook and each goes through a different rod. Hence the number

of warp threads lifted by each hook depends on the number of rods. The inventor admitted the imperfection of his machine, and especially that the cords underwent much friction and soon wore out. The next arrangement is more easily understood.

In 1862, Robert Seydel, of Gluchau, succeeded in applying the principle more perfectly. The principle of his arrangement is shown in Fig. 90 (Plate XI.). The lifting cord goes through the immovable leading points, S*o* and S*u*, of the upper and lower comber board, and also through a hole, S*m*, in the middle one, and to the vertical parts of the comber board adjustable between S*o* and S*u*. The rise of the Jacquard brings the point S*m* to point 1 and forms the figure shed. Then S*m* can be pushed horizontally to the left by a shaft machine, when the cord stretches and partly slips back through the hole, S*m*. Point 1 then comes to 2, and S*m* to 3. The sum of the lengths of the two cord branches, S*m*, S*o*, S*u*, is the same as S*o*, 2, 3, S*u*, + 3, 1, S*m*, which last is equal to the height of the shed, and goes down from the upper to the lower shed through the hole, S*u*. Fig. 91 (Plate XI.) shows the arrangement in parallel perspective. With warp sections of four, each hook, P, of the Jacquard, JM, takes four cords, which go in order to the upper board, S*o*, then to the single rods, S*m*, and so to the under comber board, S*u*.

The mails of all the cords of a rod, S*m*, are taken up under S*u*, by the lifting rods, T*h*. For five- or ten-leaved atlas there must be ten or twenty rows of holes and rods, for four- or eight-leaved damask, eight or sixteen rows, for six- or twelve-leaved damask, twelve or twenty-four rods. The warp sectioning is not considered. The distance between the comber boards is 4″, so that the cord branches make about a right angle, and the eyes are sunk so as to get a shed height of about seventy-five mm. The rods, S*m*, are kept on the right side by strong springs, and on the left are attached to a shaft machine which has also to raise the lifting rods. In the figure the first four cords are in the lower shed, the second four moved by P*h*, in the upper shed. The lifting rod, Th_1, brings binding into the lower shed, and the cord rod, Sm_5, binding into the upper shed. All cords not raised by the

Jacquard, whose rods go to the left for lowering the mails concerned, become loose, and set themselves on the lifting rods. The simplicity of this arrangement is obvious, but the wear on the cords is an objection to it. The unfavourable angle of 90° may be increased to 120° by putting the comber boards further apart (200-250 mm.), with a motion of the rods of 120-130 mm., and a shed height of eighty mm. There is then less rubbing of the cords, and this can be made still less by using rods of glass or china. Nevertheless the invention has not been adopted. The idea of bringing the comber boards further apart was, however, further worked out by Oberleitner, of Schönberg, in 1876. The author had the opportunity of seeing a loom of this design after six months' daily use, and there was no noticeable wear of holes or cords. But another circumstance, the collective pull from the raised cords of a rod, had to be overcome, *i.e.*, the cord rods must be held fast at the outer end, and be released according to the weave, and this can only be done by a special shaft machine. This problem was solved by Hohlbaum & Co., of Jagerndorf. Fig. 92 (Plate XI.) shows their machine for moving the cord rods backwards. Each rod, S*m*, is connected with the hook, *m*, by the link, *r*, at the bolt I. The nose, *n*, of the same rests at the bolt II., on the catch, K, which is kept by the springs, F, against the nose at one end and the rotating cylinder, C, at the other. A knife, *p*, swinging on I., which is moved by the rod, *y*, and the excentric, E, of the crank, H*w*, lies at the lowest part of the stroke on the noses, *n*, of the hooks, whereby K is free for a moment. The cylinder, driven by an endless screw and mechanical advantage eight and bevel wheels, Z_1 and Z_2, sets free a catch with the metal projection, *i*. The resulting pull in the rod, S*m*, presses the released nose of the hook on to the lower edge of the knife, *p*, which yields during the upward motion of hook and rod, only to be taken up again when the motion is reversed. The standing still of the Jacquard is managed as above described. Fig. 93 (Plate XI.) shows the whole arrangement. The mechanical lowering of the Jacquard is new. The Jacquard lever is made in two parts, H_1 and H_3. H_1 is loose on W_1, on to which H_3 is keyed. The connecting rod, Z, swings on H_1. When

H_1 goes down, this lever comes against the set screw, S_1, of the forked lever, H_3, which, united at 1 by the bolt 2, with the rod 6, raises the griffe. At the highest point a catch brings its nose under the bolt I., and keeps the Jacquard raised. The end of this catch is connected by a rod five with another catch, K, which springs from the point, *i*, on the other fork of the lever. H_1 hence goes up and down empty till a card on one of the projections ($Z_3 : Z_4 = 1 : 4$) driven by the cylinder of the loom, lifts the counterpoised lever, *h*, and loosens the cord, s_7, so that the spring, f_2, throws the catch III. out of gear, and those at k_1 and i_1 into gear, whereby the last couples lower H_1 and H_3 and pull down the griffe. The prism (or cylinder) which can have separate driving, is kept up in the same way, H_2 and H_5 are made alike. The arm, H_4, converts the vertical movement of the lever into the horizontal motion of the prism, P*r*. The catch at IV. keeps H_5 down at the bolt II., and so keeps up the prism. The catch, k_2, works in i_2, as soon as IV. is pulled out of gear by the spring, f_3, or the loosening of the cord, s_6, and down the prism is forced. The excentric card chain is placed according to the binding, *e.g.*, 3 : 4 : 4 weft threads. Arm *d* sits loose on EW. The lifting of the rods is done by excentrics inside the loom.

The Weigert Seydel problem for the power loom then seems to be solved. It must, however, be remembered that on account of the bends in the harness cords, the lingoes have to overcome much friction, and there is more cord tension which in wide looms, say of two metres, bends the cord rods distinctly, and the comber boards, S*o* and S*u*, have to be stiffened by being set in a frame. The inner cord tension causes the shed height to be small. The bending of the wooden rods cannot be helped, as putting them in guides is impossible with the present arrangement. The lifting rods are made strongly of steel, which cannot be supported in the harness, whereby the mails get worn through over and between the rods. This disadvantage is met by not putting the rods through the upper eyes, but connecting them to them with cords. The withdrawal of the cord rods also requires power, and wear in the rods results from the employment of heavier lingoes. The

great power required and the periodical movement of the Jacquard is apt to make the belt slip. A double source of power ensures the regular working of the loom. Besides, the projecting crank shaft end of the Jacquard driving gear must be supported, or the axle may be driven by spur gearing. The Jacquard is so far only used for raising, but with a little change in the position of the rods it could serve for lowering as well. In this case, however, the cord rod would be always loaded, and would exert an unfavourable effect on the working of the loom. Fig. 94 (Plate XII.) shows a damask loom with movable rods according to the reconstructed Weigert principle. The cord rods are divided in the middle, and work in guides so that they do not bend even in wide looms. The binding sheds are worked by two shaft machines, which contain one hook more than there are rods, S*m*, thus nine for eight-leaved atlas. Each hook is connected by a cord with a knee lever, W*h*. The long double end embraces the cord rod, and pushes it inwards for the falling of the raised figure mails. At the same time the neighbouring lifting rod, T*h*, is raised, either directly or by means of the roller and cord arrangement shown by the dotted lines. The shaft machines have the same stroke from the common roller, W, and the arms at *b*. There is only one tread for both and the Jacquard as well, which are coupled together as explained before. For power looms the lever, W*h*, can be moved right and left by excentrics. The excentrics have seven raised places and a depression. The cord angle is about 120°, the forward motion of the guides 120 mm., the rod lift eighty mm. The mails on the rod, T*h*, partly take the load from the accompanying cord rod.

Kinzer's arrangements for working without cross shedding are based on Eckhardt's, and are designed to improve upon it. They were made in Jagerndorf when, in 1895, the presently to be described ring contrivance was abandoned. They are of three kinds:—

(*a*) With healds in the cording. Instead of the rods, which require a careful choice of the beechwood of which they are made, according to the size of the holes and their smoothness on both

Fig. 94.

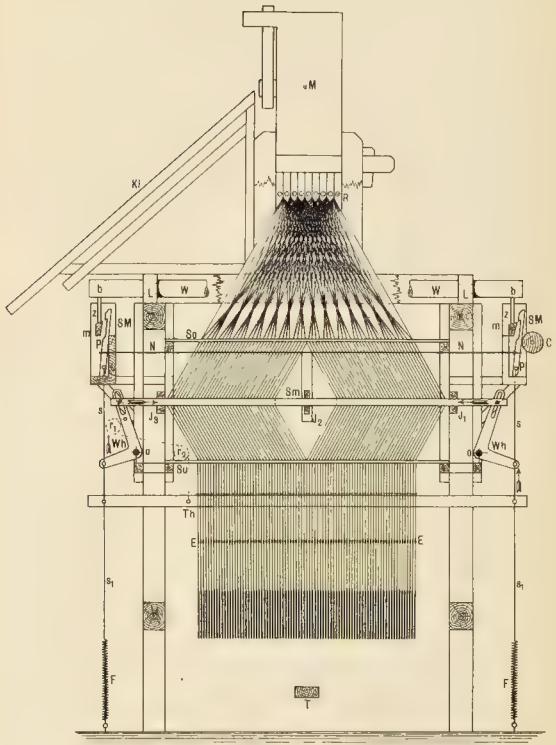


Fig. 95.

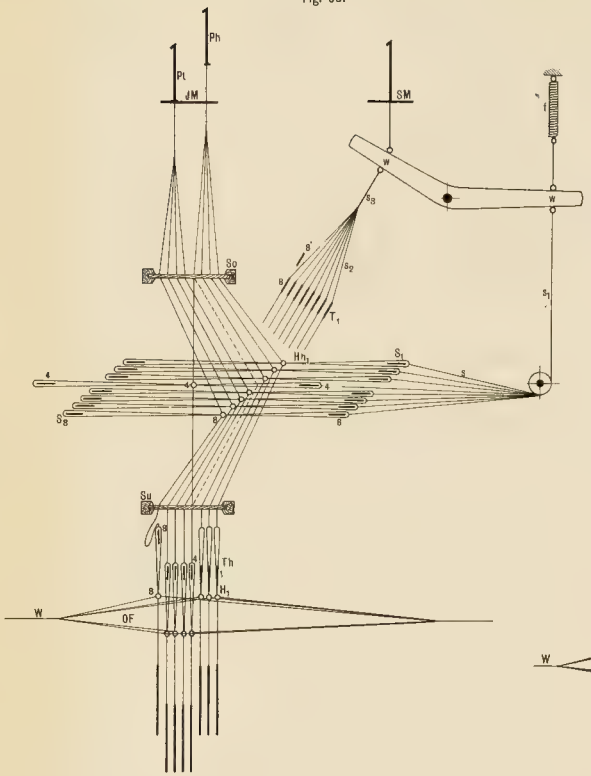
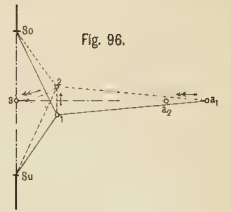


Fig. 96.



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sides, long healds with a strong mail of glass or steel are put in horizontally. They stand between the comber boards, S*o* and S*u*, in guides, but corded obliquely upwards. The mails lie therefore in an oblique plane to give the lifting cords play. By the motion of a heald the lifting cords are stretched as before, and their eyes brought into the lower shed. If the result of an investigation as to the wear of cords is satisfactory, this arrangement can be used for wide looms. The healds are accessible, and the heald rods can be embraced in the usual way for a quarter of their length by the drawing arrangement. The lifting rods, T*h*, can, by additional cording of the mails, be brought into the position T, and strengthened and supported as may be required. In Fig. 95 (Plate XII.) T_1-T_8 are accessory rods, to which the lifting rods even within the cording can be attached, two, three or four times over their length, so that no bending can happen even in a wide loom. The shaft combination also seen in Fig. 95 is intended for hand weaving. An ordinary shaft machine behind the Jacquard moves the lever W_1 of W_{11}, to the short ends of which the lifting rods are attached, and the horizontal healds to their long ends. There are eight levers for eight healds, T_1 united with S_8, T_2 with S_1, and so on. The springs, *f*, draw the healds back and support them. For wide looms, two shaft machines should be used. For power looms, the levers are worked like treads by an excentric gearing above the loom, according to the weave.

(*b*) With rods outside the cording. Instead of the horizontal healds which always cause rubbing of the cords, H. Kinzer has got rid of the friction in the rods or in the eyes and the over tension of the cords by the simple means shown in Fig. 96 (Plate XII.). The lifting cord goes through the comber board, S*o*, to the angular point 1, where it is tied to the fixed cord, a_1. From 1 both cords go together through the second under comber board, S*u*. A light lingo stretches all three parts of the cord angle uniformly. The course of the work is that point 1, by the stroke of the Jacquard, comes through a_1 in a curve to 2, and 2 by the motion of a_1 to a_2, to point 3. The difference 3, 1 to 2, gives the sinking. The continuous lines show the normal position, the dotted lines the

lowered position. Fig. 97 (Plate XII.) shows in the principle the rest of the plan. The fixed cords branch backwards at o_1, and go through the hinder comber board, S*h*, to the sinking rods, T*s*. The raised hook, P*h*, raises eyes, H_5-H_8, the cord angle at o_1 comes to o_2, and by the yielding of Ts_8 to o_3. H_8 is brought back into the lower shed, and H_4 and the accessory rods, H*s*, into the upper shed by the lifting of the rod, Th_4. Here, too, the eyes can again be corded to S*u*, and hung at H*s* outside the cording. To make this arrangement work with certainty, the bending points, *o*, are arrayed obliquely, and the fixed cords slant upwards. No ends of cords must project at *o*, or the cords might cling together. The lifting and fixer cords are best, as already stated, knotted together and put together through S*u*. A loom of this kind is still working satisfactorily. Norbert Langer & Sons took out several patents about it.

Fig. 98 (Plate XIII.) shows such a hand loom in longitudinal section. S*u* is about 500 mm. from S*o*, S*h* 460 mm. from the vertical line of the hinder edges of the comber boards, and ninety mm. from S*o*, under the upper comber board. The rods are moved by a lengthened shaft machine with symmetrically arranged groups of hooks, which move the knee levers, W_1 and W_2.

The Jacquard is simply and easily thrown out of gear. On the roller bearings of the Jacquard is a catch, K, with a spring in front of it, and at the top of the stroke hangs on the bolt, *a*, and keeps the figure shed open. The griffe of the shaft machine is raised uniformly by the cords, Z_2, Z_1, of the short roller, W. On the larger disc of the roller, N, there is a cord, Z, which at *ls* bears a leather knot over the Jacquard lever and is fixed to the tread. When the tread is depressed, the leather knot, *h*, makes the catch engage. At the same time by the roller motion, the griffe of the shaft machine is raised until a reserve hook brings the spring, *f*, and the angle, *b*, into action. K then disengages, and the griffe of the Jacquard falls. This loom works as easily as an ordinary Jacquard.

(*c*) With rods in front of the cording the already described angular cord principle can serve our purpose reversed. Fig. 99

(Plate XIII.) shows the arrangement. The lifting cord, which passes horizontally through the comber board, S*h*, to the point 1, brings the latter into T position, Ts_2, S_1, *i.e.*, into the upper shed. The letting go of T*s* brings 2 to 3 1 back into the lower shed. Fig. 100 (Plate XIII.) shows the whole thing. The Jacquard, JM, stands backwards at the loom. The grating, K, turns the vertical hook cords to the oblique direction for attachment to the slanting comber board, S*h*. The upper mails are arranged on the sinking rods, T*s*, and the lifting rods, T*h*. Mails, H_1-H_3, are brought into the upper shed by the figure hook and the angle of the cord, and H_4 by the sinking of Ts_4, from o_1 to o_2, into the lower shed, while H_8 is lifted by Th_8 into the upper shed. The movements of this special front harness consist of arrangements for raising, lowering and pausing. The fundamental idea is that the mails of one harness shall take up the warp threads, the rest being effected by means of the cording.

The principle of roller action comes next. In 1852, Groth of Berlin published a plan for improving the weaving of shawls, so as to bring the right side uppermost in the loom. Faults are easy to see in his plan, but it gets rid of the rubbing in the front harnesses. This is attained by the use of double mails. The lifting cords go through the comber board to accessory healds without eyes which can therefore not lift the warp threads direct. From here the lifting cords turn back and up over rods under the comber board to carry the usual mails. The lingo of the blind heald is twice as heavy as that of the real one, which is, therefore, always in the upper shed, until lowered by the rising of the figure shed. Both healds carry rods, and the one in the blind heald may be regarded as a sinking rod, the other as a lifting rod. The warp stands at rest in the upper shed, and the shed is formed by the lowering of the pattern warp. Hence the lowering gear of the front harness is no longer used. Three variations of this principle must now be described.

Karl Walter, of Schluckenau, was the first to make valuable use of the action of a roller for damask. In 1891 he invented the apparatus shown in Fig. 101 (Plate XIII.). To each lifting cord,

P, hangs a roller over which runs a lengthened upper mail which is held by the sinking rod at T*s* at one end, while the other is fixed to the lifting rod. If P rises, the cord of the heald is wound up, and H goes into the upper shed. If T*s* rises it goes to the lower shed. The rollers have to be very small, and that makes the cost of the apparatus heavy. In practice they are replaced by rings of steel or glass, through which the heald cords run. Fig. 102 (Plate XIII.) shows the arrangement, R being the rings. The lifting cords, s_1, are divided over the comber board, S, and again over it, to save cording. The warp is lifted in sections of four threads. At the ends hang the glass rings, R_1-R_8, through which go the cords, R*h*, connecting the rods, Ts_1-Ts_8, to the healds over the rods, Ts_1-Ts_8. The hook, P*h*, raises the figure, *i.e.*, rings R_5-R_8 and the mails to the double height. By the simultaneous lifting of T*s*, the heald of ring R_8 sinks again, and if, for example, T*h* rises, the first heald comes from the lower to the upper shed. According to this simple idea, both hand and power looms have been made. Experience has shown that ring cords of linen yarn wore out rapidly, in spite of careful choice of rings. An advantage is the half lift of the Jacquard, as the use of lifting rods only, and they arranged in a lot the number of which can be reduced by half, if, for example, Ts_1 is screwed to Th'_2, Ts_2 to Th'_3 and Ts_3 to Th'_4. This also prevents bending on wide looms, and the height of the shed can be adjusted to any kind of shuttle. The warp is sixty-eight threads to the centimetre. A reversal of the movement leads to the same result and is protected by the patent. According to Fig. 103 (Plate XIII.), the lifting cord runs over the roller to the sinking rod, T*s*, and the roller carries the heald, H. Here the Jacquard has to make an upward stroke of double extent, and the rods, T*s*, must sink, and the wear of the lifting cords is also an objection. Tittl, of Freudenthal, worked at this apparatus in 1895, and took out a patent in the name of Josef Schurz, of Seifhennersdorf. Such an arrangement is shown in Fig. 104 (Plate XIII.). The lifting cords go separately down through the comber board, and through the glass or steel rings upwards to a sinking rod under the comber board. The loom shown in Fig. 102 (Plate XIII.) is in its essential features

shown in perspective in Fig. 105. For the power loom made according to Fig. 102 (Plate XIII.), a Jacquard motion, Fig. 106 (Plate XIV.), is used. The figure shows the side turned towards the Jacquard. The catch, K, on the lever, H, hangs on the fixed bolt, B, of the frame, A, whereby the Jacquard stays up. The wheel,

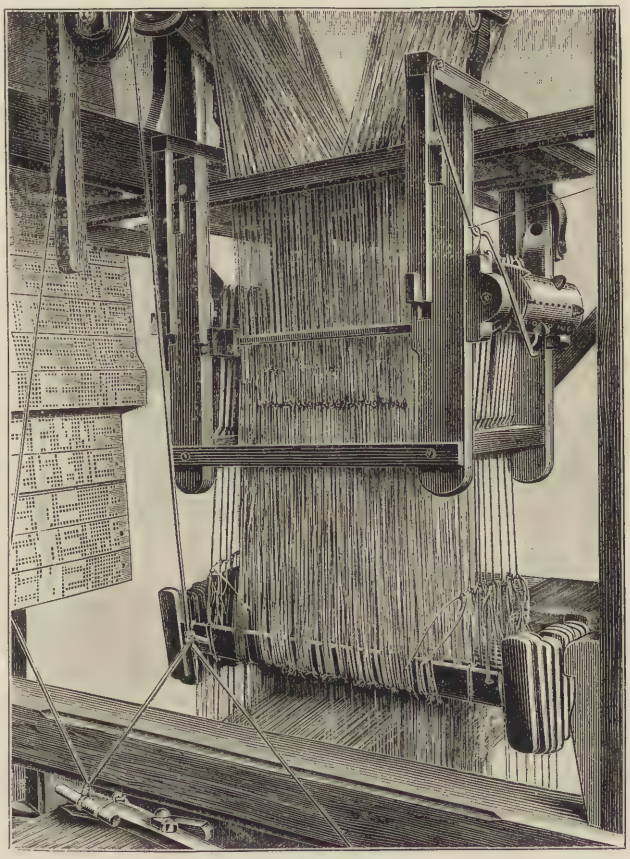

Fig. 105.

R, has tappets according to the weft closeness. For every three, four, etc., wefts they catch K, and at the moment of the lowest position of the rod, S, and the slit, O, put it out of gear, so that the griffe falls. An exchangeable spur wheel, S_{14}, in connection with the catches, K_1, K_2, and the brake, P, the lever, *h*, and the rod, *s*, causes the shifting of the tappets. Fig. 107 (Plate XIV.) shows the whole thing with loom and Jacquard. The apparatus is screwed on to the traverse, T.

Another proposal of Kinzer's for lessening cord friction and getting rid of the glass rings deserves trial (see Fig. 108, Plate XIV.). Here the ring cord is led out at a right angle and fixed at T*s*. The roller being supposed to move vertically, the harness cord lifts rollers one and two, and the heald into the figure shed. In consequence of the rectangular position the heald cord coils neither on nor off, and the heald is simply so lifted as if it were directly connected with the lifting cord. By releasing the sinking rods in a horizontal direction from T*s* to Ts_1, the heald of the cross weaving sinks correspondingly. The substitution of a right angle in the cord for an angle of 180° also lessens the rubbing. Instead of using a ring for each heald, compound damask mails, like those in Fig. 109 (Plate XIV.), can be taken, which are compelled to keep a vertical lift by the cord, *h*. But here contact with other damask eyes cannot be avoided. Hollow wooden rods (Fig. 110, Plate XIV.) with glass eyes overcome the last difficulty. In reference to this important circumstance the principle shown in Fig. 111 (Plate XIV.) might be tried. To cheapen the apparatus, small metal tubes, R*h*, with slots, and spiral springs soldered in, should be used, which are widened ovally below at X, and hung above straight on to the hook cords. Thus we get a special kind of tube healds. The horizontal cords run from the sinking rods in the tube healds to a special comber board, S*o*, from which they branch, say in fours one behind another, to the ordinary board. The tube, R*h*, is lifted, and the sinking rod, T*s*, lowered by an excentric gear, and thus the weave for the upper shed is got. The lifting rods, T*h*, lift in the usual way.

The excentric gear with the sinking rods stands on the right of the Jacquard on the traverse, so as to get room for the horizontal cords and the tubes.

CHAPTER VII.

THE COMBINATION OF THE JACQUARD WITH A SO-CALLED DAMASK MACHINE.

These arrangements have the disadvantage that the weaves neither allow big repeats nor alteration at will, unless the cording and the use of rods becomes excessively complicated. In 1859, Shields patented a Jacquard with an arrangement to get rid of cross shedding. This machine has since been repeatedly improved, and is now used in two forms in England, Barcroft's and Shields' (see Bessbrook, *infra*).

In 1882, Gunther of Chemnitz took out a patent for a non-cross-shedding loom, which was arranged as a power loom by Schönherr of Chemnitz. The arrangement allows of much variety of weave and pattern, but the construction, although highly ingenious, was too complicated, and Gunther has since altered it. The fundamental notion (Fig. 112, Plate XIV.) lies in the horizontal arrangement of the lifting cords, K_5, on which are knots, *m*. The knotted cord, K*s*, is let go at every pick, and the warp goes from the upper to the lower shed. If the movement of the knot is hindered the corresponding heald remains in the upper shed. As soon as knot is related to the ground figure, it is regularly held fixed, and when let go goes with it into the lower shed. This idea is illustrated in Fig. 113 (Plate XIV.). Every thread has its special cord, H*s*, and eye, H. The lifting cords go to cords, K, S, provided with knots at *m*, through the comber board, S*o*, over rods, r_1, r_2, r_3, through the reed, R, and are pieced partly through the pattern rods, M*s*, to the board, H*h*.

The pattern rods have a connection with the hooks of an ordinary Jacquard, but their cords are kept at the full width by

passing through the board, B_2. The rake or reed consists of small plates of iron, which just leave room between each pair for the passage of the cords, K*s*. At every pick the board, H*h*, goes horizontally as far to the right as is needed for the descent of the lower shed, and then back again to the left. If the gaps of the rake are covered in rows with thin pieces of iron, T*h* or T*s*, the cords slip through and form the lower shed, while the knots of the uncovered rows prevent the passage, and so form the upper shed.

The covering of the gaps, or rather the drawing forward of the covers, T*h* and T*s*, is done, together with the regulation of the wefts of the weft sheds, by a shaft machine with two chains of carps, one for the weave, the other for the weft shed. If, for example, the pattern rods of the Jacquard are raised, the cords also lifted, Ks_5-Ks_8 go into the lower row of gaps. Those of the unraised rods (Ks_1-Ks_4) into the upper row. The shaft machine draws the covers, T*s* and T*h*, out of the position I. to II., the board, H*h*, moves to the right, and the cords with their knots allowed to pass through R, make the lower shed with the aid of the lingoes. The cords of the uncovered rows make the upper shed. The weft is picked, H*h* goes back, and the shaft machine prepares for the next weft, etc.

The covering of the gap rows can here be done either for figure or ground, because there are hooks for each in the shaft machine. The warp sections can also be increased or diminished, so long as there is enough holes in the pattern rods. As soon as varieties of closeness are in view, the loom is rigged up, say with eight-threaded pattern rods, *i.e.*, for warp sections of eight, leaving empty healds at regular intervals. The loom under notice works with an oblique shed, and was built in 1885 for goods, 160 cm. and with 120 threads to the centimetre, of silk damask. It weaved at the rate of fifty-eight to sixty picks a minute, and its action and the quality of the fabric left nothing to be desired.

Ingenious as this plan is, the knots entail disadvantages which were fatal to its adoption, only a few looms having been used in practice.

Fig. 98.

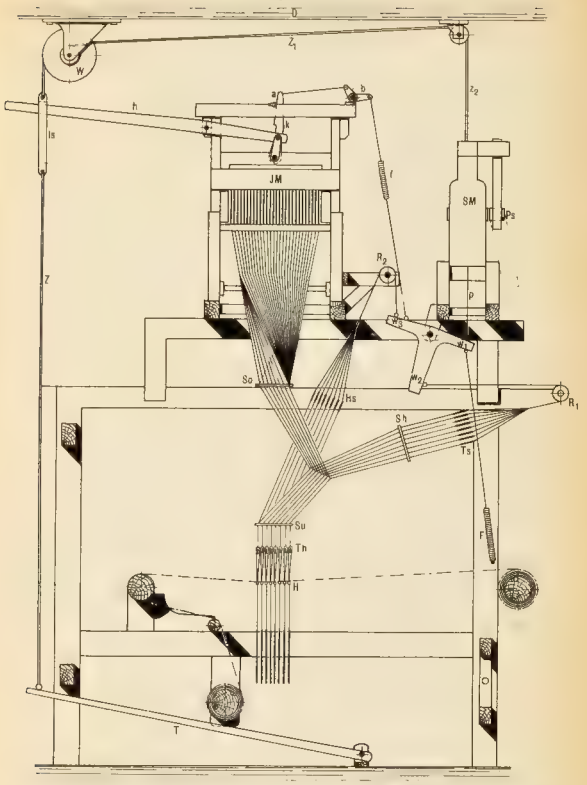

Fig. 99.

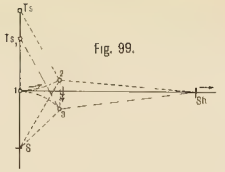

Fig. 100.

Fig. 102.

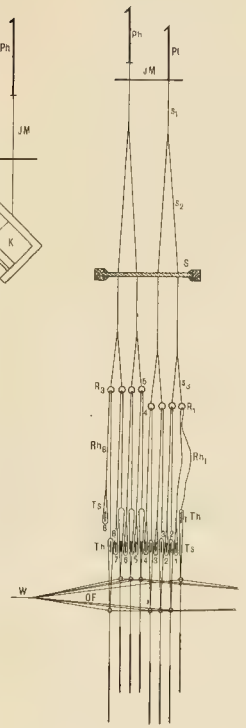

Fig. 101.

Fig. 103.

Fig. 104.

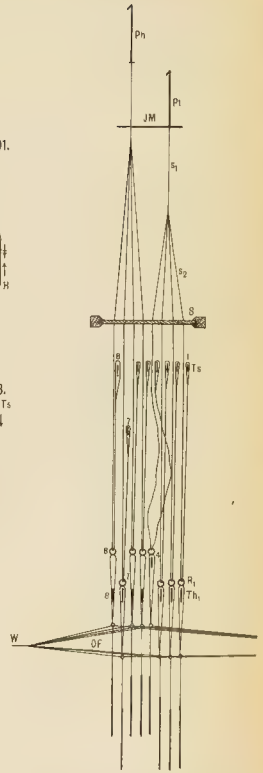

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Fig. 106.

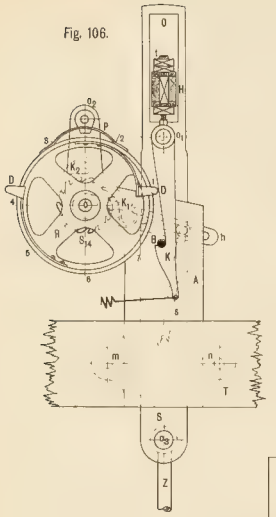


Fig. 107.

Fig. 109.

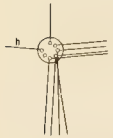


Fig. 110.

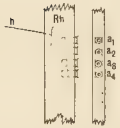
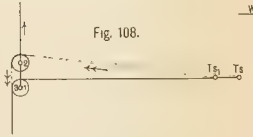


Fig. 108.



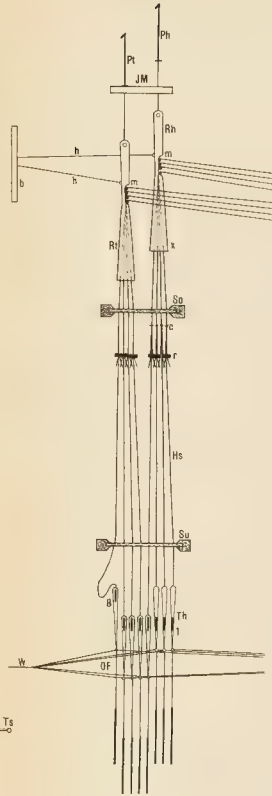


Fig. 111.

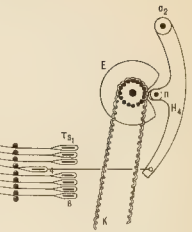


Fig. 112.

Fig. 114.

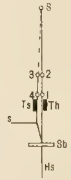


Fig. 113.

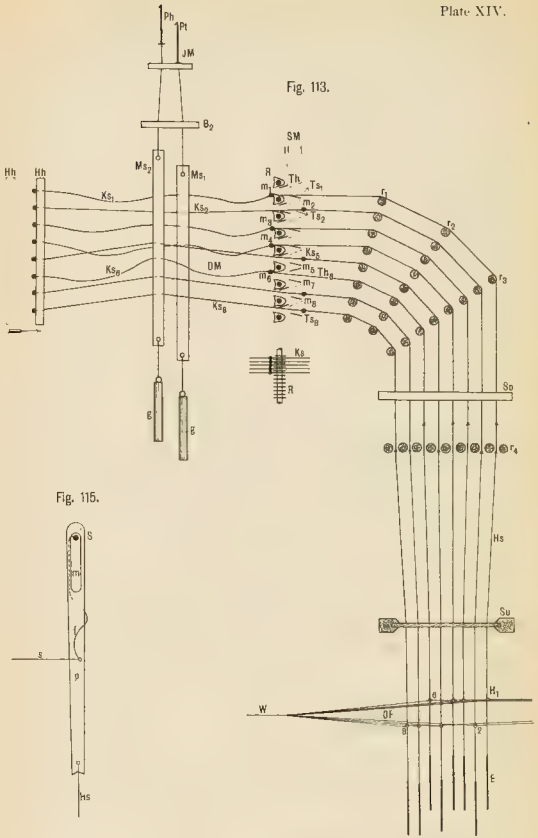


Fig. 115.

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Gunther, still pursuing the same idea, at last produced a machine which seems destined to make a revolution in damask weaving. The idea is illustrated by Fig. 114 (Plate XIV.). The lifting cord, H*s*, goes through an upper comber board, S*b*, to the connecting point, S, between the rods, T*h* and T*s*. At 1 the cord is thickened. This point when at rest is above T*h*. If it is put above T*s*, by pulling *s*, *i.e.*, at 4, it is lifted by the rods, T*s*, to 3. The rods have separate motions on which depend whether the position of rest of T*s* is down to bring binding into the upper shed or whether the lower shed forming point goes into the upper shed. Fig. 115 (Plate XIV.) shows the special construction of the pendulum hooks, *p*, made of the best quality of cardboard. They are two mm. thick, 520 mm. long and twenty-seven mm. wide above, fifteen mm. below. They hang by slots, *m*, on the rods, *s*, and change their vertical height by the operation of a Jacquard on the wire springs, *f*. In 1895 the first power loom in Chemnitz was made in Fröbel's Jacquard factory by the inventor himself. This loom is 120 cm. wide and makes seventy revolutions. It is much improved by removing the wire springs. It will now be further described in the words of Schreiber of Chemnitz, and with the aid of Fig. 116 (Plate XV.).

To avoid the difficulties caused by the working together of various different sorts of apparatus in a small space, Gunther placed the binding in a special machine put between the cording and the Jacquard. The Jacquard itself, TM, is shown sideways. With the hooks of this Jacquard cords are united at s_1, s_2, according to the size of the warp sections. These cords go through the board, S*o*, in hanging metal tubes, *r*, through which the cords of the pendulum hooks run, and by which these hooks are directly connected with the ordinary lifting cords. The pendulum hooks are arranged by their slits on the rods, S, and below they meet the lifting rods, T*h* and T*s*.

Each row of pendulums, of which eight rows are shown in the drawing, has two lifting rods. Those on the left, Ts_1-Ts_8, raise the binding warp by means of the Jacquard, *i.e.*, pendulums, p_1-p_4. Those on the right, T*h*, cause the binding of unraised warp, *i.e.*,

p_5-p_8. The regular rising of the rods is produced by hooks, which are pushed on to their knives by a special cylinder with small cards and short thick needles.

Obviously the rods, Th_1-Th_8, must work for the raised figure in warp atlas, and the rods, Th'_1-Th'_8, for the ground in weft atlas. Because a moderate pull is enough for the side pulling of the pendulum on to Ts, the cords, s_1, s_2, are not fixed direct to their pendulum, but to the upper ends of the tubes, r, swinging in rows over the lifting cords, and stand on Sb, above the holes, and are kept vertical by the tension of the lifting cords. The binding machine, DM, works with high and low warp. The rods, S, are set in a frame, while below the lifting rods, T, come upon a frame connected with S. When the shed is formed the lower frame sinks with the unlifted rods, T, as far as the lifted rods are lifted. Then the pendulums with their slits, the length of which is fitted to this double movement, slide on the rods, S. The allotment of wefts to a weft shed is done by the binding machine.

The number of rods, S, and therefore that of rows of pendulums and of the pendulums themselves, depends on the size of the Jacquard and warp sectioning and the ground weaving. For example, with an ordinary 600 machine with four thread sections we should want 2400 pendulums, and with a reserve row for a wide selvedge, 2496. For eight-leaved atlas these would be on 24 rods with 104 pendulums each. According to the inventor as many as 9000 hooks can be used. This number is rather high, but many pendulums of thin hard cardboard can be put into a row. Wear of the parts including the Jacquard and cards seems almost impossible. The cylinder and cards are only pressed against the needles just before each weft shed is formed. The changing of the cards, *e.g.*, for border and ground, is convenient for the weaver. As there is no change in the needles and hooks in the Jacquard, cards already used can be used again.

Independently of the fact, that the aim of weaving damask without front harnesses or cross shed with the use of a simple tieing, and any warp material, the method has other advantages for the manufacturer, *e.g.*, that he has it in his power to produce

differences in strength and closeness in fabrics, and different patterns with the same loom. The following will show this.

For damask in silk, wool, linen or cotton the warp sectioning may be varied, by omitting a cord at *s*, so that the section is lessened by a quarter, and yet the fabric is kept the same width and of the same pattern. If it is required to weave a narrower fabric with the same card, we leave, say, one-eighth of the cords, *s*, empty on both sides, and work with three-thread sections, so that the warp is one-quarter narrower, and the pattern the same, but one-quarter smaller. The omission of such cords can be made in vertical rows on the board, So, and this is the best plan in certain cases.

Often changes may be produced by the connection of the cords, *s*, with the pattern hooks, as for example by alternating the cords of two warp sections. The access to the places concerned is free in these operations, and that to a single pendulum is easier than to the hooks of an ordinary Jacquard. They are simply pushed on one side with the hand. Besides, as the threads of special parts are allotted to each weave, it is possible to combine various bindings in one fabric, which has not hitherto been the case. This is done by changing the binding cards. It is also possible with the same loom and warp to weave the same pattern in different damask fashions. This is easily done by altering the position of the binding cylinder. It is also possible to make long cross stripes in very different weaves.

So far plenty of plans have been proposed for the construction of damask machines. One was made by Reiser, of Aachen, in 1892, in his *Handbuch der Weberei.* The later idea of Wilke to make each needle work with as many hooks as there are threads in the warp section is its basis. See Fig. 117 (Plate XV.), where I. denotes the heald or hook, which for binding, although it is lifted for figure forming, remains in the lower shed, so that it stands still for one weft, and for the three picks following is in the figure shed. The description is as follows.

Two machines are used, one of the ordinary construction. The second contains only one cylinder to start the griffe at the right

moment. In Fig. 118 (Plate XV.) JM is the ordinary Jacquard, with four, eight, twelve, etc., rows of hooks. Here, for the sake of clearness, only two rows are drawn. Into this comes the pattern card, so that every two, three, four or more wefts are lifted once only. By the cords, *s*, and the guide, *r*, the machine is connected with the accessory machine, DM. To make the connection elastic, the cords, *s*, may be entirely or partly of india-rubber, or the needles can be fitted with springs. Another way of securing the aim of the apparatus is to shorten the stroke of JM and to turn the cylinder with a higher gear in proportion. The cording hangs with healds at DM; as each needle, *n*, of DM works with four hooks, *p*, we have a quadruple multiplication of the pattern. In weaving, the griffe rises and falls with each pick. The springs, *f*, on the needles, n_1, n_2, pull the hooks of this machine back from the knives, *m*. If JM lifts wherever the card has a hole, the corresponding needle of DM is drawn to the knife, and the hooks connected with it lift. To enable the hooks, *p*, to also weave atlas downwards the knives of this machine are adjustable. If a knife, say m_2, is altered in position the hook is not caught and remains down. The lifting of the threads for the ground atlas is worked by rods and by lifting the parts of the dissected hook frame with the use of the double number of hooks and knives. The reversal of the knife can be effected as shown in Fig. 119 (Plate XV.), with a special cylinder at the side. For this purpose the knives can be rotated on the pins, O_3, O_4. Each knife has a wire prolonged downwards and sticking into the eyes of the needles, N. As soon as this reserve machine pushes back a needle, N_3, the corresponding knife, m_3, is turned back from the normal position too far for any hooks drawn above it from catching it, so that they remain down. Without entering into the pros and cons of such an arrangement, we proceed to the further proposals in the *Handbuch*.

Repenning, of Aix, has made the following two proposals:—

(1) With cord hooks, which, as in Gunther's machine, are provided with knots. Instead of the needle and hook system shown in Fig. 118 (Plate XV.), we have here, as shown in Fig. 120 (Plate XV.), a system of cords connected with the machine, JM.

Each needle, N, is pierced with as many holes as there are threads in a warp section for taking up the cord hooks, *sp*. These cord hooks, sp_1-sp_8, hang on the lifting rods, T*h*, in the upper part of DM, and then go down through the needles, N, between the comb of rods, T*s*, through the cord ground, and hence to the warp sections through an ordinary comber board, S. The rods, T*s*, when the shed is closed, are at Ts_1, and as shown in Fig. 121 (Plate XV.) are notched above. Just over them the cord hooks have knots, K. If now, for example, N_1 is pulled, the cord hooks, sp_1-sp_4, moved in the angle, lie in the comb, with their knots over it. One of the rods, Ts_1, remains down, corresponding to the binding of the upper shed. The others rise, and together with the knots form the upper figure shed. The cords of the unpulled needles, N_2, kept their place, so that they are not moved by the notched rods. To get binding in the lower shed, one of the lifting rods (Th_5) rises. The use of knots is a disadvantage of the arrangement, so that another plan (2) was contrived with pendulum hooks. In Fig. 122 (Plate XV.) cords, H*s*, are substituted for the needles, and special hooks, *p*, are used for the cord hooks. These are made of wire and have a hook above whereby to hang them in the perforated rods, T*h*. Their lower ends are spread out for resting on the rods, T*s*. All rods receive independent motion according to the weave. We can also work high and low warp, and the lifting cords are not loosened by the rods, T*h*, on account of the forward motion of the wire hooks.

Karl Walter, of Rumberg, made a proposal in 1895, the principle of which is shown in Fig. 123 (Plate XVI.). Here the lifting cord is attached by its middle, *m*, to a lever with equal arms. One end, *s*, hangs with the sinking rod, T*s*, and the other with the healds at *n*, *n* being upon a lifting rod, *h*. If, by the sinking of the figure, *m* rises to m_1, *p* moves to *p*″, and the figure is lifted. If the same heald is to go back to the lower shed for binding of the upper shed, T*s* rises to Ts_1, and lets the lever, *p*″, swing on m_1, whereupon *p*″ takes the position p_1, and H falls. If *m* is not raised, *h* rises to h_1, and binds the lower shed. If the lift is to be in sections, a hook can be united with a corresponding number of levers by separate

lifting cords as shown in Fig. 124 (Plate XVI.). Instead of having loose connection with the rods, Ts, the levers may be arranged directly on the round rods, s_1, and the rods, h, can also be made round. The difficulty of the plan is in the arrangement of the levers. In consequence of the room they take up, the levers must be put over the cording of DM (Fig. 125, Plate XVI.), and under the ordinary Jacquard. The levers, p_1-p_8, consist of rigid iron, and every four levers lie in the slot, A, which is lifted by a hook cord. Fig. 126 (Plate XVI.) is a side view of the slot, A, and Fig. 127 (Plate XVI.) shows the levers, p, on the rods, s, of the left-hand side. The upper rods, Th, the rods, h_1-h_8, and the under rods, Ts, raise the turning points, s_1 to s_8.

CHAPTER VIII.

THE SPECIAL DAMASK MACHINE.

The complicated use of the Jacquard machine with a damask apparatus has induced other inventors to increase the number of hooks in a Jacquard, so that each needle may work with as many hooks as there are threads in a warp section, and also that the hooks are raised in rows by knives into the upper shed or left in the lower shed according to the weave, and that independently of the Jacquard lift. This idea, which first originated in the sixties, has been differently applied in practice. The use of so many hooks materially increases the size of the machine, and the object of increasing the dimensions of the pattern is not attained solely by raising large warp sections. Hence, an ordinary Jacquard does better while not occupying more space. H. Wilke, of Chemnitz, built a Jacquard in 1865 with simultaneous figure and binding lifts. At the end of the sixties a firm in Silesia made linen damask with a similar loom of their own construction. The Wilke machine is shown in principle in Fig. 128 (Plate XVI.). The machine, DM, works for each needle as many hooks as there are threads in a warp section. The hooks, p_1-p_8, have double noses, one directed towards the needleboard, the other to the griffe. The knives, m, resemble those of the Berlin double machine, but each is moved separately. The knives move according to the weave. A knife, m_5, turned to the needleboard, takes the pressed back hooks, p_5, and rises with them, but at the same time leaves those of its hooks which are pressed forwards behind. The raised hooks make a binding upper shed for the others, which in their turn make a binding lower shed for those lifted into the figure shed. The movement of the knives in Fig. 129 (Plate XVI.), as well as the

allotment of the wefts to a pattern card, is effected by a special small cylinder at the front or back of the Jacquard. Each knife, *m*, lies in a triangular notch of the griffe, and rotates round *s*. A rod, Z, connected with *m*, on the sinking of the griffe, rests on the head of the knife hook, say O_5, so that the knife position changes from I. to II. The spring, *f*, pulls the knife back again. But as soon as the needle, N_4, is pushed back, the knife, m_4, stays in its usual place. The double noses at the heads of the hooks prevent certain working, so that the machine requires great skill in handling. The cylinder acts for every weft and to turn a reserve hook as required. This machine has not found universal adoption, neither has Bessbrook's to be now described.

The principle of Bessbrook's damask machine is that enunciated by Shields in 1859, and carried out by Barcroft. It was improved by the Bessbrook Spinning Co., and now is fairly satisfactory. It is shown in Fig. 130 (Plate XVI.). The hook-heads have single noses above, and below a loop of the same length as the height of the shed, by which the hooks sit on the rods of the bottom board. Each needle, *n*, takes in several hooks, whose noses lie above the knives, *m*. If, for example, the needle, n_2, is pressed back, all its hooks remain down. If binding has to be brought into the figure a knife, say m_4, turns, being kept straight by a special needle, N, Fig. 131 (Plate XVI.), with the help of a notch, the number of knives being equal to that of the repeats. If the number of knives is greater, one needle moves two or three of them. To push back the needles there is a small separate cylinder, *pr*, with tappets, D, turned by the apparatus, K, on the right side of the machine. Hence the hooks above the knife concerned remain in the lower shed. To get binding also for the lower shed, the lower board rods, T*h*, lie in slots, *s*, of a part of the frame, S*p*. Each lifting rod, T*h*, has at each end, in the immediate neighbourhood of the slotted plate, thickened lifting hooks hung on it (r_1-r_6) which have their noses turned towards the knives, but without ever touching them. All the knives, *m*, have in front of these reserve hooks, *r*, *i.e.*, at each end a thickening which by the turning of the knife, *e.g.*, m_4, hangs the neighbouring hook, r_5, on to the next

Fig. 116.

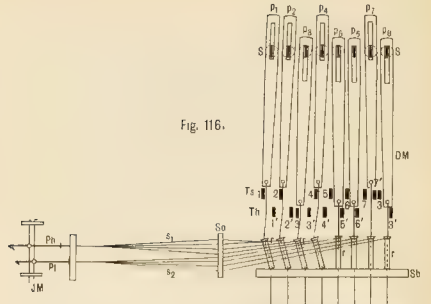

Fig. 117.

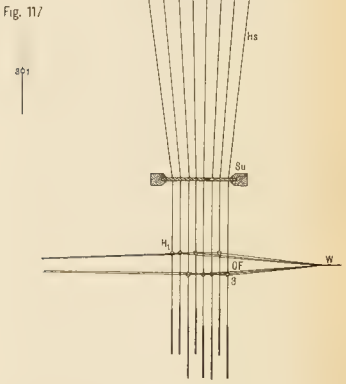

Fig. 118.

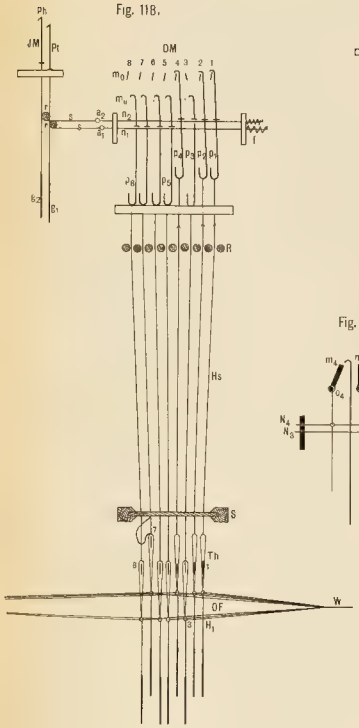

Fig. 119.

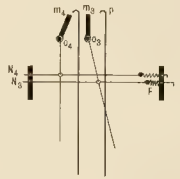

Fig. 120.

Fig. 121.

Fig. 122.

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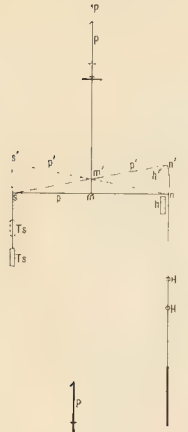
Fig. 123.



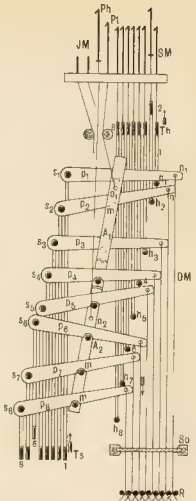


Fig. 124.

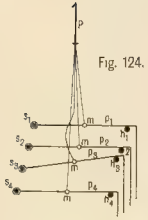


Fig. 125.

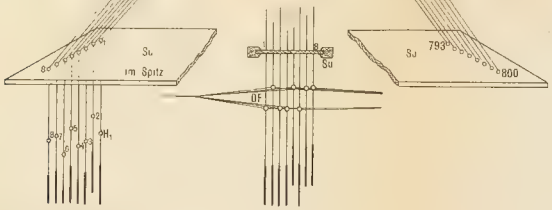


Fig. 126.

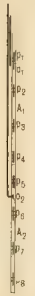


Fig. 127.

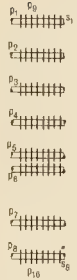


Fig. 128.

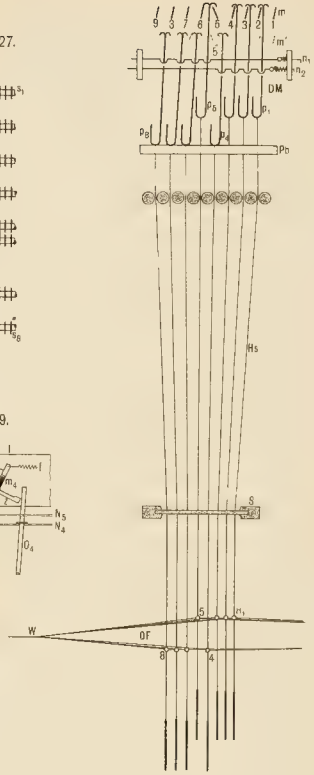


Fig. 129.

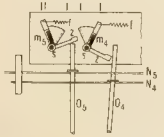


Fig. 130.

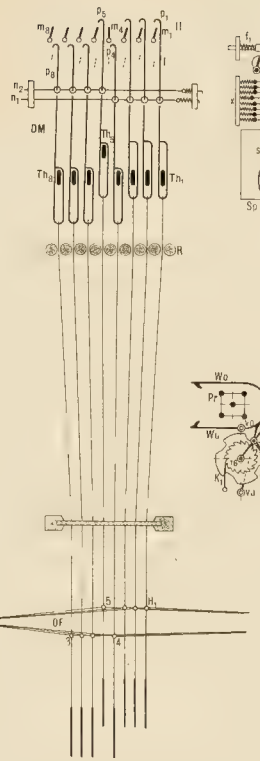


Fig. 131.

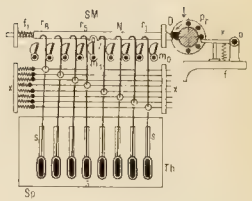
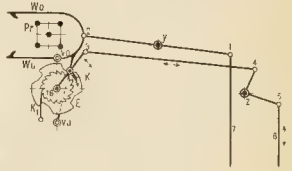


Fig. 132.



Kinzer and Walter. Damask weaving

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knife, so that Th_5 rises with it, and taking up all the hooks, p_5, over it brings binding into the lower shed. The needles, *x*, guide the hooks. For turning the main cylinder, P*r*, Fig. 132 (Plate XVI.), there is an apparatus provided. At the same time the cylinder also takes part in the rise and fall of the griffe between the hooks, *wo* and *wu*. These hooks are in one piece, and joined loosely at 2 to the lever, y_1. The lower hook, *wu*, bears two rollers, *vo* and *vu*. The upper one, *vo*, rests on the notched disc, E, with which at K a ratchet wheel of say sixteen teeth is connected. The lever 16-3 is moved by the catch at each pick, as well as by the connecting rod 3-4, and the gear 4, 2, 5, 6, attached to the crank shaft of the loom, by one tooth of the ratchet. As soon as *vo* falls into a notch of E, the upper hook comes into play, but if by a steady pull at seven, the lower roller, *vu*, is lifted, the lower hook governs the periodical motion of the cylinder. The other catch, K_1, stops the ratchet arrangement. The disc, F (? E), can be exchanged for the spur wheel 16. The disadvantages of this machine are deformation of the hooks, bending of the needles, and much friction. The simple stroke and the continual motion of the cards diminishes too the number of revolutions.

A. Morton, in 1859, got a patent for a Jacquard for damask weaving intended to save cards, and depending on increasing the number of hooks in an English Jacquard. The chief feature is the use of knotted cords, and their arrangements go to get binding without front harnesses. The machine is shown in Fig. 133 (Plate XVII.). The board, T*b*, has hung on it the cord hooks, p_1-p_3, and is fixed. Each needle, *n*, controls a hook for each thread in the warp section. Instead of a griffe there is a falling and rising frame consisting of four adjustable comber boards. The figure shows it for two needles, in the raised position and arranged for twill binding. The slots and circular holes are so placed that in the ordinary position of rest the knots are over the slots, but the retreat of a needle brings them over the circular holes, whereupon the corresponding healds remain in the lower shed, while those corresponding to knots over slots are lifted and form the upper shed. The hole sets, B_1-B_4, can be pushed to the right

or left by the connecting rods, the lever, *h*, and the cams on the cylinder, *c*. For each weft and at each stroke of the Jacquard cylinder, P*r*, two sets are moved, one to the right, the other to the left. Hence the knots are brought from the slots of B_4 to the circular holes, and bring binding into the upper shed, while in the board, B_1, the knots are brought over the slots, to produce binding in the lower shed. To present a fresh card after the fourth pick, by turning the cylinder, the upper turning hook, *w*, is connected by a rod with the lever, *o*, which by means of the excentric, *l*, brings the hook into play, that play being prevented during the next three picks by the weight, *g*. The machine is a power loom.

Pahl and Dewath's damask machine was suggested by the applicability of the English machine to damask weaving. It is shown by Fig. 134 (Plate XVII.). The adjustment of the knots is not produced by motion of the bottom board, which is a single perforated piece (Fig. 135, Plate XVII.), but an accurate working arrangement consisting of rods, m_0-m_8, standing between the cord hooks. These rods turn through a right angle, and bring the knots either over the slots, K_5, or the holes, K_4. The turning is shown in Fig. 136 (Plate XVII.). At the ends of the rods are small toothed sectors, *z*, by which the needles turn them. For this a separate cylinder is required.

In 1880, E. Hoster, of Burgwaldniel, took out a patent for a damask machine depending on the Wilke principle of the double-nosed hooks. Hoster's machine is illustrated by Figs. 137-143 (Plate XVII.). There are two knives to each hook, one on the right, one on the left, and the hooks (p_1-p_8) have corresponding right and left noses. In the position of rest the hooks are pressed to the right by the springs of the needles, *n*, so that one of the right-hand knives, m_1, m_3, m_5, etc., catches the right noses of the hooks, and raises them. If, however, the needles are pressed back the hooks go to the left, and the left-hand noses engage with the left-hand knives, m_2, m_4, etc. As the hooks are always over one knife or the other, each rise of the knives would lift all the hooks.

This would be undesirable, nor is the case improved by lifting

only the right or only the left-hand knives, for then the working would be like that of an ordinary Jacquard. There is thus a special arrangement for lifting only part of the left or part of the right-hand knives. At each side of the machine is a number of levers, H_1-H_8, Fig. 138 (Plate XVII.), in which the knives rest independently. For an eight-leaved fabric there must be eight levers on each side, lifted for every pick. The arrangement of these levers is shown in Figs. 139-142 (Plate XVII.) for four consecutive binding wefts. Fig. 143 (Plate XVII.) shows them lifted. Only those knives are lifted which lie over a nose of the levers, and close the slot entirely or completely. The others, which lie over a depression in the levers, remain down. If, for example, an eight-leaved atlas, according to Fig. 143 (Plate XVII.), is to be woven, seven-eighths of the right-hand knives are lifted, and one-eighth left down, while only one-eighth of the left-hand knives are raised. The right-hand knives bring binding into the upper shed, the left-hand ones into the lower shed. At the following weft other eighths of the knives are raised or lowered, according to the weave. If, for example, all the needles entered holes in the card, all the hooks stand to the right, or if they all stand to the left we get a smooth atlas fabric, in the one case a warp atlas, in the other a weft atlas.

For moderate-sized patterns this machine gets rid of cross shedding in a perfectly satisfactory manner, but unfortunately even a small Hoster machine of 400 needles requires for four thread warp sections no less than 1600 hooks and sixty-four knives. This is a serious drawback to the principle of the machine, which is the exact reverse of that of Gunther's machine with hanging hooks.

In the eighties, Josef Tschörner, of Kesmark, recurred to the idea of hooks with two noses. The firm of Carl Wein, of Kesmark, made the machine, and patented it in 1887, and made some improvements in later years. They have succeeded in getting power damask looms to work at the previously unattained speed of 160 revolutions. The loom was exhibited at Glasgow and attracted some attention. It works with open high and low

shed, taking in four wefts with each. The largest number of needles that can be advantageously used in the loom is 400, with warp sections of four. Hence it is only available for simple damasks. The most important part of the action of the Tschörner-Wein loom is shown in Figs. 114, 145 (Plate XVII.). The number of rows of needles is eight in a 200 machine, so as to reduce the width of the machine by one-half. Each row of hooks except the upper ones are acted on by independently moved knives, T*s*, and also, by means of the noses, N, on the lower part of the hooks, *p*, by independently moved lifters, T*h*, which form a hook floor. There is a needle for every four hooks. If all the knives are raised and the hooks not pressed back, all the hooks, p_1-p_8, are lifted, so that the action of the lifter, T*h*, is prevented. But if all the hooks are forced back, and the upper knives thus put out of action, the hooks remain on the bottom board rods, T*h*, although all the knives, T*s*, rise, and are lowered half a shed height when the knives fall. If T*h* is raised, it lifts all the hooks. There is nothing gained but making all the knives and lifters rise and fall together, with the hooks, as that makes no binding. A small number of the knives descends, according to the weave of the figure, and a similarly regulated number of the lifters, T*h*, rises. The remainder fall. For the following pick, knife, Ts_4, for example, descends, while Th_8 rises for binding, and Ts_2 and Th_6, previously raised, go back, and with the rest maintain an unaltered position. After four wefts all knives and lifters return to the middle position, m_2, to begin afresh with a new card, whereupon the separate motion of the knives is repeated. This working with an open shed means more rapid weaving. The knives, T*s*, and the lifters, T*h*, are guided by gratings in the front and back of the machine, the hooks by a slotted board, R. The movement of the knives is effected by eight lifting cams, E*k*, Fig. 145 (Plate XVII.), set in motion by the levers, 1, o_2, V, and the connecting rods, Z_2, as well as by the levers, *w*, o_3, T*s*, and the eight levers, T*h*, are moved by the cams, E*s*, by means of levers, o_1, *r*, *t*, and wires, Z_1, and also the levers, *q*, o_3, T*h'*. All sixteen cams are on a common roller, *o*, close together, and under or over the loom. The cylinder

is worked by the excentric motion in an 8·1 gear. The cylinder is only pressed during the change of the shed.

The cams, E*k*, show at F*s* the middle position of the roller, *r*. The higher places, 3, 4, 5, 6, 7, 8, 1, mean the lifting of the knives, T*s*, and to the descent of the knives, Ts_2. The excentric cam, E*s*, shows at F*s* the middle position of the roller, *r*, of the lower lever for the necessary simultaneous closing of the shed by the rods, T*h*. The lower points, 3, 4, 5, 6, 7, 8, 1, mean the sinking places of the knives, Th_2, the rise of Th_6. The discs, E*k* and E*s*, might be replaced by a shaft machine united with or placed close to the Jacquard. To get another ground weave, the stroke of the discs must be adjusted accordingly. The binding, of course, corresponds to the number of knives. Reiser proposed for the upper shed the already mentioned separately adjustable knives (Fig. 119, Plate XV.) to simplify matters by replacing the lever systems.

With the standing shed the warp threads are little damaged, as they remain motionless during several picks, the friction and wear of the cords in the comber board is considerably lessened, and the productive power of the loom is increased. This is also the case with the machine of T. H. Garvie, of Zyrardow, in which the advantages of the Barcroft-Bessbrook machine and those of the Tschörner-Wein machine seem to be combined.

The essential part of the Garvie machine (Fig. 146, Plate XVIII.) is the arrangement of a second but fixed griffe, *mf*, with movable knives, mf_1-mf_8, set in motion by a special arrangement of hooks (Figs. 147 and 148, Plate XVIII.), with their needles, n_1, and cylinder. The knives of the movable griffe, m_1-m_8, rotate on their long axes by means of hooks, *a*, needles, n_2, and cylinder. Each main needle acts with several hooks, *p*. Hence the binding both of figure and ground is produced by the movable griffe. As an example, a 100 machine is shown in Fig. 146 (Plate XVIII.). It is for eight-leaved fabric with warp sections of four threads. The repeat of the binding must correspond to the number of hook rows.

In the griffe, *m*, the knives, m_1-m_8, which rotate on their long axes, are fixed to the hooks, *a*, so that they must move with them. The

hooks, *a*, Figs. 147 and 148 (Plate XVIII.), are worked by needles, n_1, which go from the spring box through the needle board, and strike upon an eight-sided cylinder, a reserve cylinder which either carries the binding in corresponding perforations, or is arranged for metal cards. For greater certainty, there is a similar apparatus on the other side of the knives. The knives, *m*, act according to their position on those hooks which comprise the rods, T*h*, forming the lower board of the hooks. At both front and back end of the axis of the Jacquard cylinder are small octagonal binding cylinders. These are pressed against the needle board simultaneously, so that the needles, *n*, are worked simultaneously with the ordinary needles. If a needle, n_1, is pressed back, it takes the knife hook, *a*, with it, and turns one knife, m_4; for example, see Figs. 146 and 148 (Plate XVIII.). If the griffe, *m*, is raised, the hook row corresponding with the turned knife remains down, but at the same time this knife catches under the noses of the hooks, P_5, thus lifting them together with their lower board rods, Th_5; see Figs. 146 and 149 (Plate XVIII.). Thus, of two consecutive rows of hooks, one is always up and the other down. By this we get the binding in the ground with the raised hooks, that in the figure by the lowered ones.

The hooks, *p*, have, as can be seen in the drawing, two noses, I. and II., the lower ones, II., catch the movable knives and rise with them and the griffe, so that the upper ones, I., catch the knives of the fixed griffe (Fig. 146, Plate XVIII.). The hooks remain on these fixed knives during several picks, whereby the repeated lifting after each weft of the warps needed for forming the figure is avoided, and the machine works with an open shed. If at a following pick one of the upper hooks is pushed back by its needle, it falls from the knife, *mf*, back into the lower shed.

The hooks needed for the binding in the upper shed are lowered as follows: The knives, *mf*, are closely fastened to hooks, *b*, by the eyes, *c*, and with them are acted on by the needles, n_2. The hooks, *b*, are hung pendulum fashion at *o*. If one of the needles, n_2, is pressed back by the binding cylinder, the knife, say, mf_4, connected with the needle by the hook, *b*, will fall, so that all the

hooks hanging to that knife go into the lower shed. The order in which this takes place determines the binding. Fig. 149 (Plate XVIII.) shows the row p_4 left down and p_5 lifted. Fig. 150 (Plate XVIII.) shows p_4 again lifted.

To enable, besides, several wefts to correspond to one card, the turning hook, *w*, of the large cylinder, P*r*, has in front a projection, *g*, which presses against a small iron cylinder, C. The latter is placed in a slide, L, receiving motion from an excentric on the crank shaft by means of a lever. At each revolution of the shaft the cylinder, C, makes one-eighth of a revolution, and as L moves vertically, the cylinder is brought at every weft against the projection, *g*. C carries cards into holes in which *g* may not enter or may enter, according as to whether the turning hook is to be raised or not. In the latter case the Jacquard cylinder, P*r*, turns and a new card is set at work. In the former case when the turning hook is lifted by an unperforated part of the card, the card of the Jacquard cylinder is not changed. The reserve cylinders turn at every pick.

Although this machine is simpler than the Tschörner-Wein, and works open shed in contradistinction to the Bessbrook, there is no high and low warp arrangement, so that the hooks have no steady fall, but fall abruptly on to the lower board from the pull in the lifting cords, a circumstance which leads to several inconveniences and among them to a slow rate of work.

The Combination of Two Systems of Cording.

The principle of the angle in the lifting cord, together with Kinzer's improvement on the Weigert Seydel arrangement, has its advantages. We will therefore close by mentioning such an arrangement which enables various sizes and various bindings to be secured without the use of modified Jacquards, and by means of a suitable combination of figure tieing with binding tieing, and combination of both with an accessory horizontal tieing, doing the work of a warp. It was invented by H. Kinzer in 1896, and is the nearest approach as yet to fulfilling the aims of damask weaving, *i.e.*, the production of large patterns with few

hooks and cards, and of any variety of ground binding in the same figure. The inventor calls it the Triumph Damask Arrangement. It is so simple that any weaver can understand it without difficulty. It requires cords and boards, a small Jacquard, and a carefully carried out arrangement of the loom. Fig. 152 (Plate XVIII.) shows the principle of this damask contrivance.

As figure Jacquard, FJ, there is a high and low warp Jacquard machine. The figure hook, T*h*, is shown up. To every hook cord hangs the usual neck or lifting cords, passing close together through the comber board, S_1, and dividing themselves at h_1 and h_2, for lifting the warp in sections. As binding machine there is a second but smaller, about 100-hook, Jacquard placed behind the first. This second Jacquard lowers half the hooks (say one to forty), and raises half (say forty-one to eighty). Hence the harness cords of the binding machine are placed double harness fashion in the comber boards, S_4 and S_3, as if with this machine alone repeats up to forty threads were to be woven over the whole width of the fabric. Each of these three cordings has then the same number of lifts down from the comber boards. The cords, *ss*, of the second harness in the board, S_3, are knotted in regular order to the cords, *so*, of the board, S_1, at the apex III. of the angle and at points one to eight. While the figure lifting cords, *su*, go into the ordinary comber board, S_2, and take the usual mails, the cords, *ss*, run under the denomination, *sh* (CH for lowering cords of the horizontal tieing), backwards over guiding rods, *d*, or through a guiding board, and form directly behind an angle, *sw*, pointing downwards, so that like a thread warp they go through the lower-placed mails, *hh*, of the sinking cords and are finally fastened at *n* to rods or a comber board. The mails, *hh*, are kept down by extra heavy lingoes. Instead of having them, we may knot to the angle, *sw*. The work proceeds as follows: If the first harness alone rises, the angle becomes more obtuse, and the cords, *sh*, advance, and stretch the angle of the figure cords if they are up. This happens according to the repeats. If the second harness alone rises, the mails are brought from the lower into the upper shed. If both harnesses rise

Fig. 133.

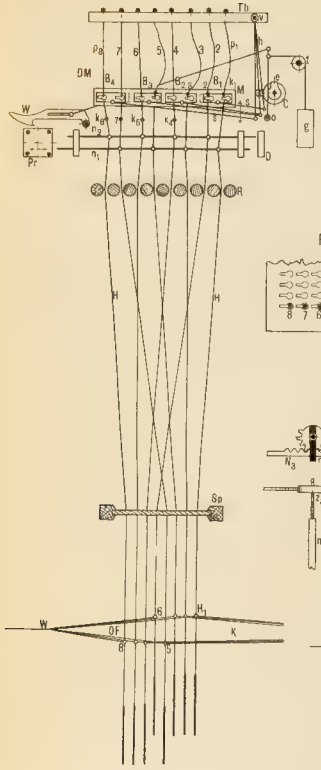


Fig. 134.

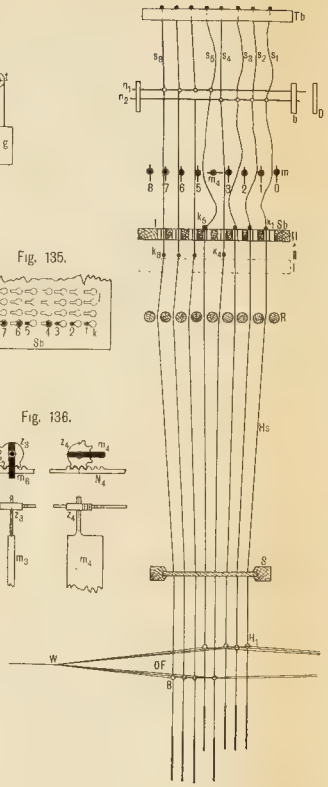


Fig. 135.

Fig. 136.

Fig. 137.

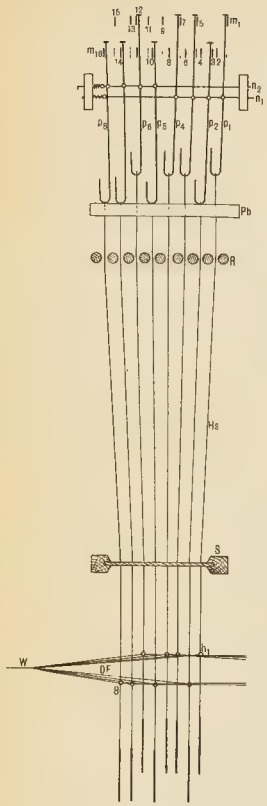
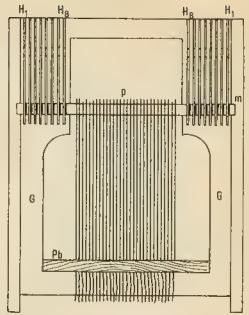


Fig. 138.



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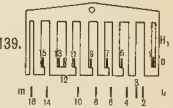

Fig. 140.

Fig. 141.

Fig. 152.

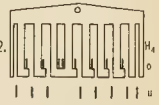

Fig. 143.

Fig. 144.

Fig. 145.

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Fig. 146.

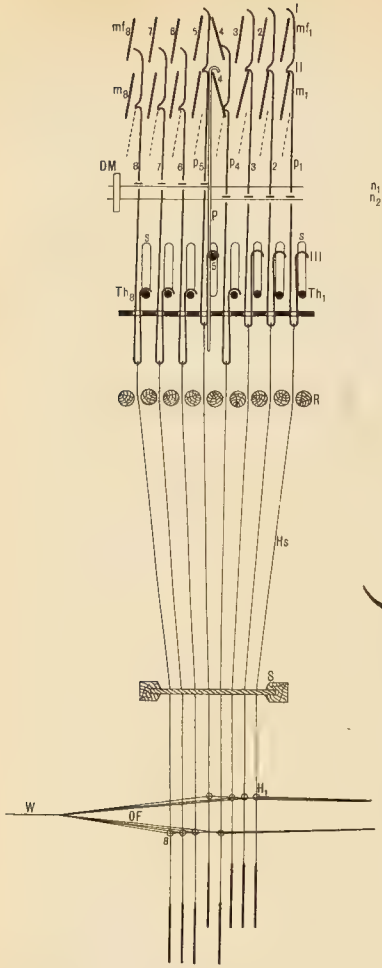


Fig. 147.

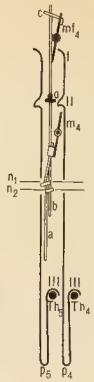


Fig. 148.

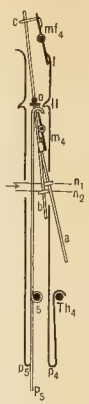


Fig. 149.

Fig. 150.

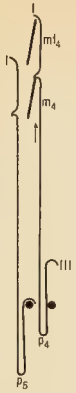


Fig. 151.

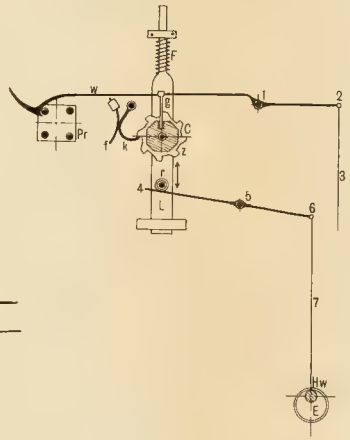
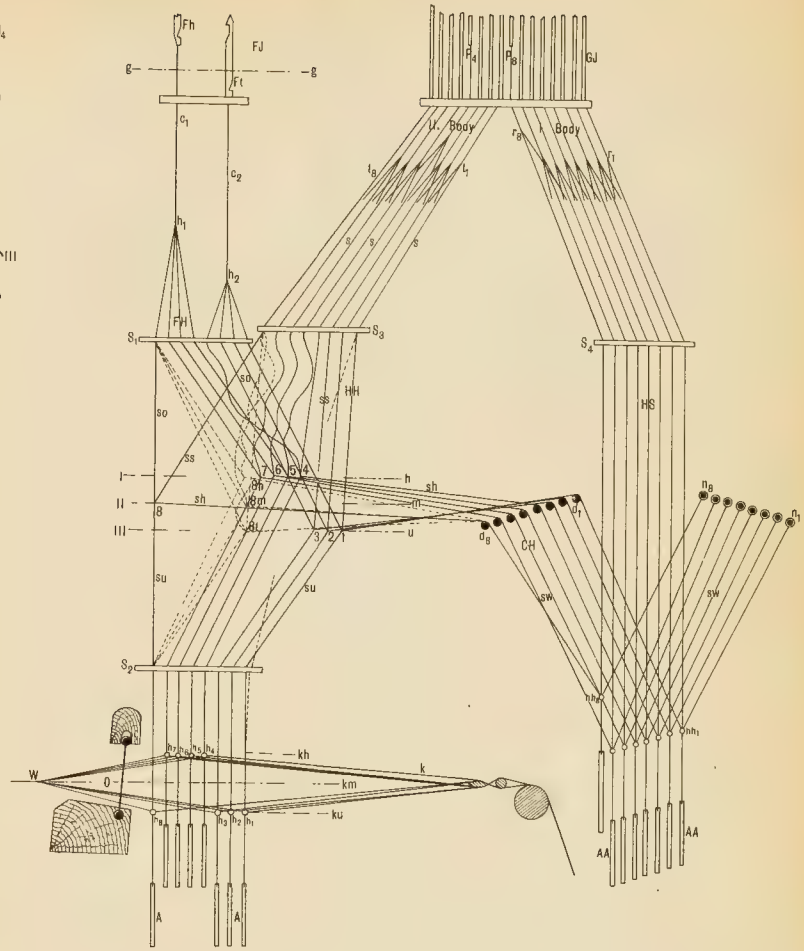


Fig. 152.



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together as well as the figure machine in accordance with the cards, we get a binding shed formed. In the plate, the mail, h_8, is lowered by the accessory mail, hh_8, and the cord sh_8, while h_4, on the contrary, is raised by the cord, ss_4. The two Jacquards are coupled together weft shed fashion, and moved by a single tread. The cords, *ss*, can also be put direct through the comber board, S_2, and tied to the mails.

CONCLUSION.

THE present tendency is to produce the handsomest and best possible quality of damask, as was shown at the Great Exhibition at Paris, and the art of weaving has progressed in order to satisfy this demand. The influence of modern taste makes itself felt in weaving as in all artistic labour. Instead of the antiquated patterns, we often see attempts at very large and effective patterns for the treatment of decorative surfaces, and these attempts give great scope to the realisation of the ideas of the artist. Unfortunately the artistic development has been checked by the exigencies of the loom. To remove this difficulty is the object of the mechanics of weaving, and not least in damask weaving, and the present work offers welcome assistance in this direction.

The variation in the outlines of damask patterns of whole sets of threads at a time was regarded as a drawback, as long as the pattern consisted of small shapes. The use of larger Jacquards diminishes the evil, but with an increase of cost which is not made up, for by the resulting improvement the taste for large patterns directs its attention to regular outlines, and hardly pays any heed to the unessential point of the stepping of the outline. For these large patterns damask weaving offers a field capable of great development, and it will therefore be largely used for the production of decorative fabrics. Damask weaving, then, cannot be regarded as an obsolete and worn out art, but will be used in the future with great effect in the manufacture of table linen, furniture stuffs and carpets. The commercial production of these articles will find its increase as these objects are attained. Hence every one concerned in the trade should make himself familiar with

the technical appliances recognised as good, as their skilled use will inevitably bring profit. The present work shows not only that the attempt to perfect damask weaving has been made, but that we have succeeded in directing it by channels which will permit of uninterrupted progress.

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